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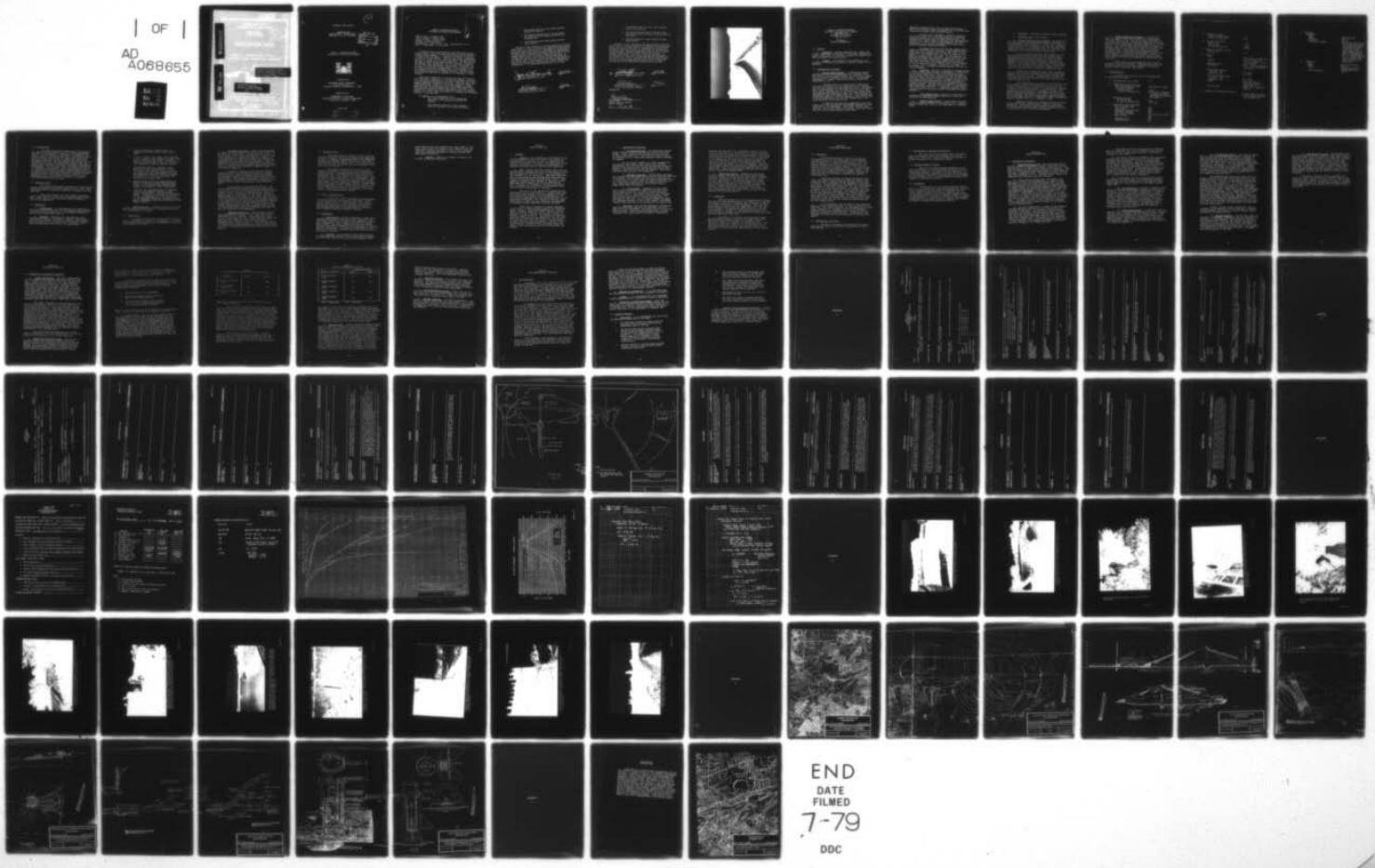

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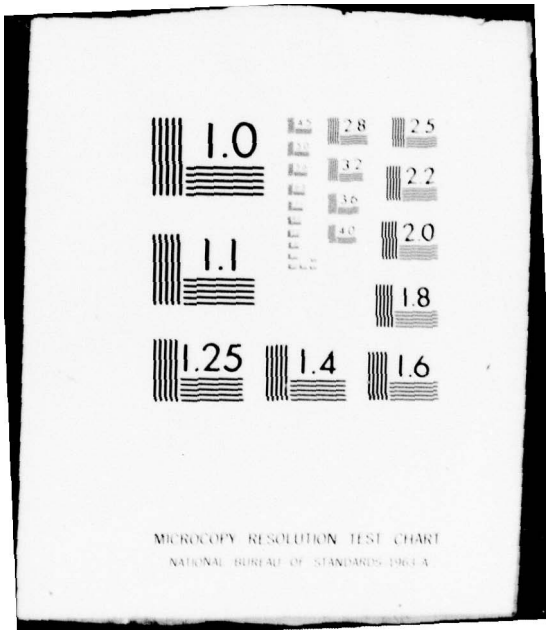
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LEVEL

DELAWARE RIVER BASIN
IRONWORKS CREEK, BUCKS COUNTY
PENNSYLVANIA
ID NO. PA. 00789

IRONWORKS DAM

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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National Dam Inspection Program.
Ironworks Dam, Delaware River Basin,
Ironworks Creek, Bucks County,
Pennsylvania (ID Number PA. 00789)
Phase I Inspection Report.

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

JUNE 1978

(12) 92 p.

DELAWARE RIVER BASIN

IRONWORKS DAM
BUCKS COUNTY, PENNSYLVANIA
NATIONAL I.D. NO. PA 00789

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared by:

WOODWARD-CLYDE CONSULTANTS
5120 Butler Pike
Plymouth Meeting, Pennsylvania 19462

Submitted to:

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

June 1978

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam: Ironworks Dam
County Located: Bucks County
State Located: Pennsylvania
Stream: Ironworks Creek
Coordinates: Latitude 40° 10.6' Longitude 74° 59.7'
Date of Inspection: 6 June 1978

ABSTRACT

Ironworks Dam and Springfield Lake have been in continual service since 1944 and are owned by the Philadelphia Suburban Water Company. It has been classified as having a "High" hazard potential. Based on the visual inspection, evaluation of the records, and past operational performance, the dam is judged to be in good condition. The dam was not designed to pass the probable maximum flood as required by the Federal (OCE) Guidelines, but it does pass 70 percent of the calculated PMF without overtopping. Therefore, the spillway is considered "Inadequate". If the parapet wall is reconstructed to accommodate additional storage, or if the emergency spillway is lowered one foot, this structure could pass the PMF and be upgraded to an "Adequate" classification.

The visual inspection of the dam and reservoir facilities detected no symptoms of uncontrolled seepage, instability, significant deterioration or other conditions that would suggest impending hazardous conditions. Some wet zones were noted downstream in addition to the development of woody vegetation on the downstream slope and emergency spillway. Some upstream riprap sloughing was noted. The Owner's 1976 studies have identified these conditions as well as remedial measures to correct them and methods to increase the discharge capacity of the spillway.

ABSTRACT

In summary, it is recommended that:

1. The woody vegetation on the downstream slope and in the emergency spillway be removed.

2. The riprap be restored on the upstream slope of the dam to its design elevation.

3. The parapet wall near the right abutment should be restored.

4. The channel downstream of the principal spillway should be rehabilitated as soon as practical.

5. The downstream wet zones should be monitored yearly.

Because of the location of the dam upstream from populated areas, a formal procedure of observation and warning during periods of high flow or development of potentially hazardous conditions should be developed and implemented. An operational maintenance procedure should also be established together with an annual inspection program. A resident dam tender lives within the drainage area and is charged with reporting the development of abnormal conditions as well as the necessity for routine maintenance. This daily surveillance should significantly reduce the probability of an undetected malfunction of the dam.

John H. Frederick, Jr., P.E.
Maryland Registration 3701

8/2/78
Date

William S. Gardner, P.E.
Penna Registration 004302E

8/2/78
Date

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for John H. Frederick, Jr., P.E.
Maryland Registration 3701 — Date 7/19/78

William S. Gardner P.E.
Penna. Registration 004302E — Date 7/19/78

APPROVED BY:

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

DATE: 31 Jul 78

OVERVIEW
IRONWORKS DAM, BUCKS COUNTY, PENNSYLVANIA

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
IRONWORKS DAM
NATIONAL ID #PA 00789
DER NO. 9-137

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Ironworks Dam creates Springfield Lake by the impoundment of Ironworks Creek. The reservoir stores approximately 1995 acre-feet of water over 172 acres of reservoir surface area. The watershed encompasses 5.7 square miles and elevations range from about 350 to 132.

Ironworks Dam is a rolled earth filled structure with a concrete core wall keyed within the bedrock. The core wall extends to the embankment crest. The embankment is approximately 745 feet long, has a 15-foot wide crest and is approximately 51 feet above the valley floor. The upstream and downstream slopes are fully protected by hand-placed riprap and dumped rock fill. The upstream and downstream slopes are 2H:1V and change to 3H:1V and 2 1/2H:1V below elevations of 132 and 129, respectively. The crest elevation of the dam is 139.

A concrete ogee structure supported on the foundation rock forms the primary (principal) spillway at the south end of the embankment. The curved 110-foot long spillway, has a crest radius of 100 feet. The crest elevation is 132 feet above Mean Sea Level (MSL).

Reservoir discharge flows over the ogee section into a small stilling basin which discharges into a 440-foot-long concrete and rubble paved spillway channel.

An auxilliary (emergency) spillway located at the extreme north end of the dam provides an increased discharge capability during maximum design storms. Designed with a riprap crest at elevation 136, the emergency spillway crest has a width of approximately 210 feet. Downstream, a one percent discharge slope blends into a natural (unpaved) downstream channel.

A minimum flow rate of 10 mgd for public water supply is discharged into Ironworks Creek through the intake tower via a skimming weir around the tower. Water passes over the skimming weir into two 12-inch cast iron pipes to a 20-inch cast iron pipe. If the reservoir is below the skimming weir elevation, water enters the tower through two intake gates and is transferred to the 20-inch cast iron pipe. This pipe conducts the water beneath the dam through the diversion tunnel and discharges it into an aeration chamber. Thereafter, the water is discharged via a riprapped discharge channel into the natural streambed.

b. Location. The dam is located on Ironworks Creek in Bucks County, near Holland, Pennsylvania, in the vicinity of the intersection of Route 532 and Holland Road. State Highway Route 09044 (Churchville Road) crosses the reservoir about 3000 feet upstream from the dam and about 4000 feet upstream from the dam, the Newton Branch of the Philadelphia and Reading Railroad crosses the reservoir. Parallel with the railroad and on its upstream side is a township highway. The dam site and reservoir are shown on USGS Quadrangle, Langhorne, Pennsylvania, at coordinates N 40° 10.6' and E 74° 59.7'. A Regional Location Plan of Ironworks Dam and Springfield Lake is enclosed as Plate 1, Appendix E.

c. Size Classification. The dam is classified as Intermediate consistent with a height of 51 feet and a reservoir of 1995 acre-feet.

d. Hazard Classification. A High Hazard classification is assigned because of the potential for extensive property damage and loss of life downstream of Ironworks Creek.

e. Ownership. Philadelphia Suburban Water Company.

f. Purpose of Dam. Water supply.

g. Design and Construction History. Available construction records indicated earth filling operations for the embankment began in November of 1941, after removal of the subsoils and decomposed rock within the embankment foundation area. It is probable that the core wall excavation also began several months prior to initiating the embankment fill and was carried to intact rock.

A grout curtain was constructed below the core wall trench by pressure injecting a neat cement grout through 404 holes located from 0.5 to 7 feet on-center. The holes were staggered and offset one foot up- and downstream of the core wall centerline. Each hole was carried to an average depth of 39 feet below the stripped surface. Grout, with a water-cement ratio ranging from 2 to 3:1, was injected at a pressure of about 35 psi and yielded an average take of 18 bags of cement per hole.

Reportedly, stream diversion, after stripping and grouting of the dam foundation area, was accomplished through a 42-inch O.D. cast-in-place outlet conduit supported on the rock surface. Subsequently, the concrete core wall and spillway structure were constructed on the intact foundation rock.

The embankment was designed to be partially zoned by placement of more impervious materials on each side of the core wall and by placement of progressively coarser materials out towards the edge of the embankment. However, a review of the records did not document the specified zoned construction procedure. Embankment materials were derived from the designated borrow areas, but the records did not document the borrow source and placement schedule. The intake tower gates were closed May 1, 1943, and the reservoir reached full pool on January 4, 1944.

Records indicate that Ironworks Dam was designed by the Philadelphia Suburban Water Company Engineering Department. Final design drawings were also prepared by the Philadelphia Suburban Water Company together with specifications and other construction documents.

h. Normal Operating Procedures. At normal pool, water is supplied downstream through the intake tower over the skimming weir. The water is then conducted via a 20-inch cast iron pipe through the diversion tunnel into the aerator and eventually discharged downstream. A cross-section of the intake tower and the aerator is shown on Plate 6. The rate of flow through this 20-inch cast iron discharge pipe is controlled by a valve at the base of the intake tower. This valve was calibrated and the discharge rate is determined by the number of valve turns. If the reservoir is below the skimming weir elevation, water supply is maintained by two sluice gates at elevations 122 and 107 which are connected to the 20-inch cast iron pipe.

Excess water is discharged over the principal spillway at the right abutment. Although never used, the emergency spillway, at the left abutment, has been designed to carry abnormally high flows.

1.3 Pertinent Data.

A summary of pertinent data for Ironworks Dam is presented as follows:

a. Drainage Area (sq. miles)	5.7
b. Discharge at Dam Site (cfs)	
Max. Known Flood at Site	900 (July 15, 1975)
Principal Spillway	
At Top of Dam	8,600
At Top of Parapet Wall	14,925 est. (assumes no reduction resulting from construction at bridge)
Emergency Spillway	
At Top of Dam	320
At Top of Parapet Wall	9,173 est.
c. Elevations (feet above MSL)	
Top of Parapet Wall	142
Top of Dam	139
Emergency Spillway Crest	136
Principal Spillway	132
Max. Pool of Record	133.8 (July 15, 1975)
Water Supply	106
	121
Emergency Drain	90
Skimming Weir	132

d.	Reservoir (miles)	
	Length @ Normal Pool	1.0
	Fetch @ Normal Pool	0.3
e.	Storage (acre-feet)	
	Normal Pool	1,995
	Top of Dam	3,409
	Top of Parapet Wall	4,132
f.	Reservoir Surface (acres)	
	Normal Pool	172
g.	Dam Data	
	Type	earth with concrete core wall to elev. 139
	Length	745 ft. (without spillway channel)
	Maximum Height	51 ft. (above foundation)
	Top Width	15 ft. (including parapet wall)
	Side Slopes upstream	
	above El. 132	2:1 (H:V)
	below El. 132	3:1 (H:V)
	Side Slopes downstream	
	above El. 129	2:1 (H:V)
	below El. 129	2.5:1 (H:V)
	Cutoff	Core wall footing approximately 10 ft. below rock line
	Grout Curtain	Double row, staggered spacing
h.	Diversion and Regulating Tunnel	20 inch cast iron pipe 8 inch diameter to maintain minimum flow

i.	Spillway	
	Principal	
	Type	Ogee type weir
	Length	110 ft.
	Elevation	132 ft.
	Downstream Channel	Channel has stoney bottom, some bank erosion and meanders through tree/brush covered flood plain which is approximately 500 ft. wide. Approximately 2000 ft. downstream of dam, the stream passes under a road bridge; homes are built on flood plain
j.	Emergency	
	Type	Earth/Rock Channel
	Width	202 ft.
	Length	Approximately 600 ft. along centerline
	Crest Elevation	136 ft.

2.2 Construction.

Reviewed construction documentation was limited to a series of miscellaneous letters, notes and memoranda. The date of commencement is unknown and is assumed to be early in 1975 or, possibly, late 1974. Construction photographs indicate that the dam and appurtenant structures were most likely constructed in general accordance with the design drawings. Records indicate that the dam was completed June 30, 1976, and photographs indicate that construction was performed by James D. Morrissey, Philadelphia, Pennsylvania. The only significant diviation noted was in the gradation of the riprap. This is discussed in Section 3. Construction records and field testing records were not available from the designers/SCS Project Engineer for review. In consideration of the good condition of the dam and sufficiency of other data obtained from DER files, it was determined that it would not be necessary to attempt to retrieve the additional SCS data.

2.3 Operation Data.

The construction permit indicates that the discharge system must maintain a minimum stream flow of 1.5 cfs. The discharge system is reportedly designed to maintain this minimum flow.

Since the reservoir has only reached the conservation pool elevation, there are no discharge records available. There was no other operational data available at the time of inspection.

2.4 Evaluation.

a. Availability. All engineering data reproduced in this report and studied for this investigation were provided by the Pennsylvania Department of Environmental Resources and the Soil Conservation Service.

b. Adequacy. The design data provided was quite comprehensive and well documented. However, construction data was very limited, and details confirming that construction was performed in accordance with the design requirements and specifications could not be ascertained.

5. "Safety Evaluation, Ironworks Dam", by Woodward-Clyde Consultants, dated July 30, 1976.

6. A letter from Mr. C.E. Davis, Vice-President to Mr. C. Ryder, dated January 10, 1944. This letter states that the gates to Ironworks Dam were closed on May 1, 1943 and the reservoir reached full pool on January 4, 1944.

7. A memorandum from Mr. C. Weigle, Chief, Division of Dams, dated January 7, 1944. This letter indicates that several sources of seepage have developed downstream of the dam immediately after the reservoir reached an elevation of 21 feet on the staff gage located on the intake tower.

8. Specifications filed with "Application for Permit to Construct a Dam Across Ironworks Creek", by the Philadelphia Suburban Water Company, dated March 7, 1938, three pages.

9. "Contract for the Construction of Ironworks Creek Dam, Northampton Township, Ducks County, Pennsylvania", (83-page document, undated). Contained in this data are references to, but no documentation of the properties of the embankment materials, engineering analysis of embankment stability and details of the design criteria.

b. Design Features. A complete description of the design features of this project is discussed in Section 1.2, "Description of Project".

2.2 Construction.

A complete description of the construction history is presented in Section 1.2, paragraph g. A description of the foundation materials and embankment materials are described as follows.

Foundation Materials. Boring records document the depth to "rock" below the original grade surface to be from 5 to 27 feet and to average about 11.5 feet. It is not known if the "rock" indicated is the top of relatively weathered or unweathered material. However, it is probable that at least the residual soil horizon was removed during the foundation area stripping. Thus, the foundation of the dam can be conservatively assumed to consist of weathered and decomposed, but relatively dense rock, principally from the arkosic sandstone member of the Stockton Formation.

Outcrops of bedrock in the spillway channel, immediately below the dam were identified as a medium to fine grained, arkosic sandstone containing primary constituents of quartz and feldspar with mica as a secondary mineral. The exposed rock generally exhibited a limited depth of weathering alteration, evidenced by the reddish coloration and friability of a thin surficial zone.

Structurally, the Stockton Formation is part of an extensive monocline and was observed within the area of the site to be flat-lying with the bedding dipping slightly east of north at an average slope of about 15 degrees. As the alignment of the preferred jointing is approximately at right angles to the stream flow and the joints observed are relatively tight and in some instances, filled by secondary mineralization, the secondary porosity of the foundation rocks normal to the dam would be expected to be moderate to low. The decomposed sandstone, which becomes less altered with depth, is rated as being relatively incompressible under the embankment load and does not contain any known structural features which would impair the stability of the embankment.

Embankment Materials. The available construction documentation relative to soil type indicates the embankment soils to include: silty sand (SM), silty clay (CL) and sandy silt (ML). These materials, when compacted, would be expected to exhibit permeabilities generally, in a range of 1×10^{-4} to 1×10^{-6} cm/sec. The associated shear strength based on effective stress would be expected to be characterized by friction angles ranging from 31 to 34 degrees and an effective cohesion from 0 to 200 psf.

2.3 Operation Data.

Preconstruction data used to design Ironworks Dam contained flow records of Neshaminy Creek from 1884 to 1932. A summary of Neshaminy Creek flow records was presented on documents which included the years 1884 through 1913 and 1932 through 1936. It is reported that this data was used to develop hydrologic/hydraulic analysis for this project.

The construction permit, as well as other supporting documents, indicates that the discharge system must maintain a minimum stream flow of 10 million gallons per day. This minimum flow is controlled by a calibrated valve at the base of the control tower. The operator is given instructions as to the number of turns to turn the valve to achieve the required flow at Neshaminy Creek. Minimum flows are requested from the Neshaminy Creek Water Gaging/Treatment Station, located downstream on Neshaminy Creek. There were no records available documenting when and how the 20-inch valve is operated. Reservoir levels are recorded daily and transmitted to the Neshaminy Water Station.

2.4 Other Investigations.

In the early 1970's, Woodward-Clyde Consultants of Plymouth Meeting, Pennsylvania, performed a comprehensive investigation of Ironworks Dam. The scope of work included a review of all available documentation, several dam inspections and an engineering analyses. The engineering analysis included stability evaluation and a complete hydrologic/hydraulic analysis.

2.5 Evaluation.

a. Availability. All data reproduced in this report and studied for this investigation were provided by the Pennsylvania Department of Enviormental Resources, Harrisburg, Pennsylvania, by the Owner, Philadelphia Suburban Water Company, Bryn Mawr, Pennsylvania and from records and data developed by Woodward-Clyde Consultants of Plymouth Meeting, Pennsylvania. The Owner's representatives were available to provide information about the construction and operation of the dam.

b. Adequacy. As previously stated, several pieces of information were extracted from construction documents and from field observations performed by Woodward-Clyde

Consultants during the preparation of their report. This data, coupled with this recent visual inspection and the hydrologic analysis performed as part of this investigation, are considered adequate to evaluate the dam and appurtenant structures.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The observations and comments on the field inspection team are contained in the Checklist, enclosed herein as Appendix B and are summarized and evaluated as follows. In general, the appearance of the facility indicated that the dam and appurtenances are properly maintained and in generally good condition.

b. Dam. During the visual survey, there were no indications or evidence observed of distortions in alignment or grade that would be indicative of movement of the embankment or the foundation. Some down-slope movement of the riprap on the upstream slope was noted at a few locations as shown on Photos Nos. 7 and 9. This movement is evident when compared to Photo No. 8 which shows the riprap slope at the end of construction. This condition is attributed to the age of the structure, the degree of inclination of the upstream slope and the loss of riprap due to vandalism.

The crest of the dam was well maintained and considered to be in good condition. Several large evergreen trees were observed on the downstream slope and are apparently well-rooted into the embankment. The minor riprap displacement on the downstream slope is not considered significant. No evidence of bulging, crest distortions or other features indicative of embankment or foundation shear distortion could be detected.

There was no evidence of seepage emergence in the form of flowing springs noted on the downstream slope. However, beyond the downstream toe, several small wet marshy areas were noted. There was no flow emerging from the areas and no evidence of previous boiling or piping of fines. The location of these wet areas are shown on Sheet 5a, Appendix B. The wet areas were noted in previous inspections (1973) and ranged in size from 2 to 4 feet in diameter. The elevation of the water surfaces approximated the elevation of the outlet stream. Probing of the wet, marshy areas indicated a firm bottom approximately 18 inches below the surface.

c. Appurtenant Structures.

1. Principal Spillway. No significant seepage either through or around the spillway structure was observed. Minor concrete spalling was noted at the base of the stilling pool weir. The concrete channel section was observed to be in excellent condition with no evidence of seepage.

At the contact between the rubble pavement and the natural rock channel, some erosion has occurred. Concentrated flow has loosened and transported downstream blocks of the jointed rock, undermining the paving and forming a receding scarp across the channel. This phenomena was noted during a 1973 inspection.

2. Emergency Spillway. The emergency spillway was in generally good condition and highly resistant materials (to erosion) were estimated from previous investigations to range from 4 to 6 feet below the existing spillway crest. It is noted that several trees, as shown in Photo No. 6, have established themselves in the spillway channel. These trees should be removed.

3. Outlet Works. Inspection of the outlet works revealed no signs of significant distress within the diversion tunnel or the outlet conduit contained within the tunnel. The intake tower was also inspected and found to be in exceptionally good condition. Some spalling was noted, but it is minor and expected in a structure of this age. At the contact between the paved and riprapped sections of the outlet channel, some deterioration was noted but it is considered to be superficial.

d. Reservoir. The railroad embankment crossing the upper potion of the reservoir has partially isolated a section of the impoundment, essentially forming a stilling basin upstream. During previous inspections, records documents that random probings indicated a substantial

sediment build-up which has undoubtedly reduced the useful storage capacity of the reservoir. Further upstream, this siltation has essentially created deposits which have become marshy and support the growth of grass. The extent of silting within the remaining reservoir is unknown but it is reported by the Owner that a recent bathymetric survey of the reservoir was performed to determine the remaining storage capacity of the impoundment. This survey revealed significant quantities of sediment below the normal pool level but insignificant sediment above normal pool level. Flood storage capacity has not been significantly affected by sedimentation.

e. Downstream Channel. Immediately downstream of the principal spillway and the outlet works channel, the water flows in a rocky gravelly bed with no evidence of major erosion below the spalled zone noted in Section 3.1, paragraph c. The stream meanders and there is some minor stream bank erosion between the dam and the first bridge downstream. The channel meanders and narrows through Holland passing very close to homes which are built within the flood plain. Both sides of the approximately 500 foot wide flood plain are predominantly tree and brush covered.

3.2 Evaluation.

With the exception of the limited areas of sloughing riprap on the upstream slope, the inspection of the dam disclosed no evidence of apparent past or present movement to indicate instability of the embankment. The soft, wet areas observed just beyond the downstream toe of the dam do not appear to be associated with potential piping of the foundation. Records of inspections performed in 1973 indicate that no changes in the condition of these wet areas have occurred since that time.

The degree of spalling of the spillway channel and the spillway crest is typical of a dam of this age. The conditions observed within the discharge channel do not appear to represent an immediate hazard to the integrity of the dam. However, it is concluded that the downstream channel should be stabilized at some time in the future to prevent further deterioration of the channel bottom.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures.

The maximum reservoir level is regulated by the skimming weir at the intake tower and the primary spillway each with a crest elevation of 132. Water for public consumption is drawn-off the skimming weir, discharged through a 20-inch pipe into an aerator and allowed to flow down the natural channel. The flow through this 20-inch pipe is regulated by a valve located at the junction of the intake tower and diversion tunnel. This valve has been calibrated and the resident caretaker adjusts the valve as necessary to produce the required downstream flow.

Should the reservoir be below the skimming weir crest, two intake pipes located as shown on Plate 6, are opened and water is passed through the same 20-inch pipe to maintan flow requirements to the Neshaminy Creek Treatment Plant. Excess water above elevation 132 is discharged downstream via the primary spillway. An eight inch pipe regulated by a valve at the base of the intake tower can be used to drain the reservoir. This valve was exercised during the inspection and observed to operate properly. It is reported that this drainage pipe is exercised at least one or more times per year. The other valves within the intake tower are operated several times per year, particularly during the low flow conditions associated with the late summer months.

It is understood from the Owner's representative that no written procedures exist for the operation of Ironworks Dam. The normal procedure, as discussed with the caretaker, consists of a telephone call from the Neshaminy Treatment Facilities requesting that a certain volume of water be released from the reservoir. Subsequently, the caretaker will open the valve accordingly to satisfy this demand.

4.2 Maintenance of the Dam.

The dam is reportedly maintained by the Owner's personnel who check the structures periodically and perform repairs.

4.3 Maintenance of Operating Facilities.

The valve control mechanisms within the intake tower and diversion tunnel were observed to be clean, painted and lubricated. Each valve was exercised and observed to operate in a satisfactory manner.

4.4 Warning Systems in Effect.

There are no formal warning systems or procedures established to be followed during periods of exceedingly heavy rainfall. As reported by the caretaker, if a hazardous condition develops or if high flow conditions are anticipated, the Owner's representative or an engineer at the Bryn Mawr office of the Philadelphia Suburban Water Company is immediately notified.

4.5 Evaluation.

Although there are no written operating procedures, it is believed that the current operating procedures are a reasonably realistic means of operating the relatively simple control facilities at Ironworks Dam. A formal warning procedure and surveillance program should be implemented during periods of extreme rainfall or during the development of a hazardous condition so that residents downstream could be amply warned of possibly high volumes of flow or a potentially hazardous condition.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features.

a. Design/Evaluation Data. The design data available was limited to statements located in the State Files, particularly in the Application Report, dated June 30, 1936, and the results of flood routing through the reservoir. However, in 1972 Woodward-Clyde Consultants, at the request of the Owner, prepared a report evaluating the safety of Ironworks Dam (Reference No. 5). Included in this report was a comprehensive hydrologic/hydraulic analyses.

(1) The original drainage area, as listed in the Application Report, was determined at 6.4 square miles and based on a USGS map surveyed between 1883 and 1885. The area supported by current USGS maps is approximately 5.7 square miles, the difference being partially attributed to grading operations during development of the reservoir and subsequent development within the drainage area. The watershed is leaf-shaped, 3.5 miles long and 1.2 to 3.0 miles wide. Elevations range from 370 feet in the upper reaches to 132 feet at the reservoir normal pool elevation. The area is at least 50 percent residential and is growing. Most of the remaining land is open with very little woodland. Five small, one to two acre, ponds are upstream of the reservoir and will have no effect on the reservoir during an extreme event.

(2) Prior to construction, a model of the principal spillway and waste channel was built and tested at the Pickering Creek Plant. The capacity of the principal spillway, as stated in the Application Report, was about 9700 cfs with the water in the reservoir one foot above the top of the earth embankment and two feet below the top of the parapet wall. The capacity of the emergency spillway is about 4200 cfs with the reservoir water level at that elevation. The combined discharge being equivalent to a runoff of 3.35 inches per hour.

The maximum runoff routed through the reservoir was 3.85 inches per hour. This raised the water surface from 132 to 140 in just under four hours, equivalent to a runoff of 15.4 inches.

(3) The report prepared by Woodward-Clyde Consultants reviewed the original rating curves for the spillways and found them reasonable. The "top of parapet wall" discharge for the principal spillway is an extrapolation of the rating curve which assumes the service road bridge has no effect (based on the geometry of the chute at the location of the bridge) on the discharge capabilities of the principal spillway. The PMF was also determined (based on a drainage area of 6.4 square miles) from a 24-hour storm producing a peak inflow value of 18,649 cfs. Computations are shown in Appendix C.

(4) In accordance with the criteria established by the Federal (OCE) Guidelines, the recommended spillway design flood for this "Intermediate" size dam and "High" hazard potential classification is the probable maximum flood (PMF).

(b) Experience Data. Records of reservoir water levels are kept at the downstream Neshaminy Plant and in the Owner's office in Bryn Mawr, Pennsylvania. Reservoir levels are taken by the Owner's personnel at the dam. A review of the more recent records back through 1974 disclosed a maximum reservoir level of 133.8 feet on July 15, 1975. This corresponds to a discharge of 900 cfs. This discharge was associated with four days of rainfall totaling 4.29 inches measured at the Neshaminy Water Treatment Plant. Verbal reports indicates that the reservoir water level has never reached the emergency spillway crest, elevation 136.

(c) Visual Observations. On the date of the inspection, the only conditions observed that would indicate that the outlet capacity could be reduced during a flood occurrence is the presence of large trees growing in the approach channel and at the concrete sill in the emergency spillway. Observations regarding the condition of the downstream channel, spillway conditions, and reservoir are located in Appendix B.

(d) Overtopping Potential. The original design data, as stated in the Application Report, implies that the structure would be overtopped during an extreme event and may be capable of withstanding overtopping of the earth embankment without failure of the parapet wall, at least for a short time. The 1976 Woodward-Clyde report indicated the embankment to be overtopped by 1.4 feet, also assuming the parapet wall does not fail. However, in view of the fact that the parapet wall experienced movement and that there are cracks and a gateway opening, it is conservatively assumed that the parapet wall is not capable of retaining water.

The Woodward-Clyde Consultants (WCC) report included a routing of the PMF through the reservoir. The maximum elevation of water in the reservoir is computed to be 140.4 feet. This is 1.6 feet below the top of the parapet wall (see Appendix C). It is noted that this peak inflow (18,460 cfs) was based on a 6.4 square mile drainage area as listed in Bulletin No. 5, "Dam, Reservoir and Natural Lakes", Department of Forests and Waters, Harrisburg, Pennsylvania, 1970. Therefore, when the peak flow is scaled down based on the reduced drainage area, this inflow reduces to 16,826 cfs. The PMF inflow hydrograph developed conservatively assumed no retardance effect of the highway and railroad embankments. As the bridge openings through the embankments is less than the flow area of the spillways when the reservoir water level is at the top of the dam, the embankments will attenuate the peak inflow value.

Further, the WCC studies demonstrate that enlargement of the emergency spillway capacity is feasible. The enlargement could consist of either lowering and/or lengthening the existing crest.

(e) Spillway Adequacy. The spillway system of this dam is considered "Inadequate" but not "Seriously Inadequate", as the embankment overtops during passing of the calculated PMF. The spillway systems can discharge 70 percent of the calculated PMF without overtopping. A lowering of the emergency spillway by one foot would enable the system to pass the calculated PMF. The tailwater is estimated to be 40 feet below the top of the embankment during passing of the PMF.

(f) Downstream Conditions. Approximately 2,000 feet downstream of the dam, Ironworks Creek passes under Chinquapin Road, which is expected to flood when discharge from the dam is somewhat greater than 5,000 cfs. At Chinquapin Road and approximately 1,000 feet further downstream at Holland Road, houses are built on the flood plain and are subject to flooding. Immediately above Holland Road, Ironworks Creek joins with Mill Creek. Many homes and businesses are located adjacent to Ironworks Creek between Holland Road and Neshaminy Creek (2.3 miles downstream of the dam) and are subject to flooding every few years.

Residential dwelling density increases significantly below the confluence of Ironworks Creek with Neshaminy Creek. Damage, including loss of life, to downstream sections would be significantly greater if the dam failed during passing of the PMF than the damage resulting from large flows if the dam does not fail during passing of the PMF.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. The visual observations did not indicate any existing embankment stability problems. However, it is noted that at a few locations the riprap slope upstream appears to have been displaced down slope and should be repaired. Although soft wet areas were noted beyond the downstream slope, there is no evidence indicating that these conditions are potentially hazardous. An inspection performed in 1973 indicated identical conditions with those observed during this recent inspection. Therefore, it is judged that potentially hazardous conditions are not developing nor is it believed that monitoring of these seeps other than normally associated with routine inspections is warranted.

The visual inspection of the spillways did not reveal any evidence of instability at the ogee weir in the principal spillway or in the riprap control section in the emergency spillway. Some minor spalling was observed on the ogee weir and some channel deterioration was noted below the principal spillway discharge channel. Considering the age of the structure, this spalling is not considered to be potentially hazardous. However, it is concluded that repairs should be performed to minimize further deterioration. Similarly, the deterioration noted downstream of the principal spillway is also judged not to be immediately hazardous. It is concluded that the channel should be stablized as soon as practical. Trees were noted within the spillway channel and should be removed to assure maximum efficiency if a low frequency storm is experienced in this drainage basin.

The intake tower was observed to be in good condition together with the diversion tunnel. All of the piping was also observed to be in good condition.

b. Design and Construction Data. The records in the State Files did not contain formal stability or seepage analyses associated with the design of this dam. However, letters of correspondence indicated that such analyses were performed. During the safety evaluation studies performed by Woodward-Clyde Consultants, this lack of design documentation was also noted. There-

fore, as part of that investigation, stability evaluations were performed. Records of these evaluations are contained in the Owner's files in Bryn Mawr, Pennsylvania. Summarized below are the results of these studies.

Conditions which have led to the failure or have severely restricted the performance of dams similar to Ironworks Dam were analyzed as part of that investigation. The failure conditions considered to be the most critical included the following:

1. Shear failure of the embankment;

2. Failure by piping through, around or beneath the embankment; and

3. Failure by overtopping of the embankment by floods exceeding the capacity of the spillway outlet systems.

The first two conditions are discussed in the following sections. The third condition was discussed in Section 5.

1. Shear Failure. The potential for shear failure or excessive shear distortion of the embankment was investigated using the as-built geometry of the most critical embankment section. The pertinent properties of the materials were conservatively established from data obtained in the daily construction reports, located at the Bryn Mawr, Pennsylvania office and from a limited source of reported test data, also located at the Bryn Mawr office. Based on these files, the embankment soils were assumed to be predominantly silty sand or sandy silts (SM or ML) as per the Unified Soil Classification System. The bracketing shear strength parameters selected for that analysis are tabulated below.

TABLE 1
PARAMETERS FOR EMBANKMENT STABILITY ANALYSIS

PROPERTY	CASE 1	CASE 2
Effective Cohesion (psf)	0	100
Friction Angle (degrees)	35	30
Total Unit Weight (pcf)	130	130

The shear strength parameters were derived for effective stress conditions.

The stability computations were conducted using the simplified Bishop method of slices for failure planes with a circular arc configuration. The post-configuration embankment loading conditions investigated during the study corresponded to steady-state seepage conditions, seismic loading and sudden drawdown conditions. It is noted that the later condition is not credible because of the limited discharge capacity of the 20-inch diameter outlet pipe and the eight inch drainage pipe, but this was evaluated for comparative purposes. Stability during the maximum probable earthquake was evaluated using a psuedo-static horizontal force equivalent to 12 percent of the embankment mass, exceeding the requirements of the U.S. Corps of Engineers seismic zone classification.

The results of Case 1 and Case 2 analysis conducted for the bracketing soil parameters are summarized in Table 2 for both the downstream and upstream embankment slopes. There was no credit taken for the effectiveness of the concrete core wall in depressing the downstream phreatic line.

b. Adequacy. As previously stated, several pieces of information were extracted from construction documents and from field observations performed by Woodward-Clyde

TABLE 2
SUMMARY OF STABILITY ANALYSIS

ANALYSIS CONDITION	FACTOR OF SAFETY	
	CASE 1	CASE 2
Steady Seepage (DS)	1.9	2.2
Steady Seepage (US)	2.3	2.6
Seismic Loading (DS)	1.4	-
Seismic Loading (US)	1.4	1.7
Sudden Drawdown (US)	1.5	1.6

(DS) = Downstream (US) = Upstream

The results of the stability analysis indicates that the embankment is stable, even under seismic conditions greater than that which have regionally occurred within the recorded historic past. This conclusion is consistent with a detailed embankment survey documenting the absence of noticeable bulging, settling, misalignment, cracking of the embankment, or any other features which would reflect post-construction shear distortion. The only noted distortion is downslope slippage of the upstream riprap slope.

2. Piping Failure. Piping failure by seepage through, under or around the embankment was investigated during the Owner's 1973 investigation considering the possibility of cracks in the embankment and core wall as well as seepage through interconnected open joints or fractures within the foundation rock. Inspection of the core wall alignment along the crest revealed no evidence of cracking of the exposed wall extension or subsidence around the wall. The downstream slope and the ground surface several hundred feet downstream from the toe of the embankment was carefully inspected during that investigation. That survey revealed small wet areas discharging minute and, in most cases, imperceptible quantities of seepage. Apparently this seepage was noted during an investigation performed in 1963. The description in that investigation indicated

that no changes have occurred since then. Similarly, during this 1978 inspection, no change was observed. There is no evidence that an existing piping failure through, beneath or around the embankment exists at the Ironworks Dam site.

c. Operating Records. It is noted that since construction, there is no record of flow over the emergency spillway. The Owner does maintain water level records which are transmitted to the Neshaminy Water Treatment Plant downstream on Neshaminy Creek and supplied information as to maximum reservoir water elevations.

d. Post-Construction Changes. Other than the rehabilitation of the foot bridge across the principal spillway, there were no reports nor is there any evidence that modifications or alterations were made to the dam.

e. Seismic Stability. As noted in paragraph a, the seismic stability of the dam was investigated. It is noted that the seismic stability exceeds the minimum requirements established by the Federal (OCE) Guidelines. Therefore, it is judged that the structure satisfies seismic stability requirements.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Assessment. The visual inspection and the long-term performance of Ironworks Dam indicates that the dam embankment and foundation has and is performing satisfactorily and is in good condition. The wet zones located just beyond the toe of the dam have apparently been there at least since the inspection of 1963. Comparing the descriptions of these areas with the condition of the wet zones during this inspection, it is concluded that a serious hazard does not exist which could affect the integrity of the dam. The spalling of concrete along the discharge channel is expected considering the age of the structure.

An inspection of the intake tower and the diversion tunnel indicates that these structural features appear to be in good condition. Similarly, it was observed that the structural integrity of the principal spillway and retaining walls were also in good condition. As noted on Photo Nos. 10 and 11, some lateral upstream movement of a 30-foot section of the parapet wall was observed near the right abutment of the dam. Based on this visual inspection, the cause for this unusual movement could not be ascertained. It is noted that the maximum movement observed is on the order of four inches and descreases to zero approximately 30 feet from the end of the wall. At this location, a vertical crack was observed. As a result of this rotational movement upstream, a small section at the top of the left abutment retaining wall of the principal spillway has also been moved. This movement can be observed in Photo No. 11. Although it is not believed that this condition presents a serious hazard to the dam, it is concluded that this wall should be restored.

The evaluation of the hydrologic and hydraulic features of this structure was performed using the data developed by Woodward-Clyde Consultants. As previously noted, the data indicates that the structure passes 70 percent of the PMF.

These calculations assume no effect on inflow characteristics by the highways and railroad embankment which cross the reservoir. These features would retard the peak inflow time on the hydrograph, and most likely reduce the PMF. These computations were not performed because an assessment of the probable results indicates that the structure would still not pass the PMF. Therefore, the spillway would still be classified as "Inadequate". As the dam is overtopped during a PMF event, it is judged that overtopping would be of short duration; the core wall and downstream riprap slope would provide at least some protection to minimize the potential for catastrophic failure.

b. Adequacy of Information. It is concluded that the information available for this assessment is adequate.

c. Urgency. It is considered that the recommendations presented below be implemented as soon as practical.

d. Necessity of Additional Studies. Since the Owner's previous studies were quite comprehensive and have identified the conditions noted during this inspection, it is believed that further investigation would not significantly contribute to the assessment of Ironworks Dam.

7.2 Remedial Measures.

a. Facilities. It is recommended that the following measures be undertaken by the Owner:

1. All vegetation should be removed from the emergency spillway channel and from the downstream slope of the dam.

2. The deteriorated channel sections downstream of the principal spillway should be evaluated and rehabilitated as soon as practical. This rehabilitation could merely require the placement of large riprap designed to withstand high flow conditions. Alternately, rock anchors could be used.

3. Spalled concrete on the principal spillway channel should be repaired during normal maintenance operations.

4. The displaced section of the parapet wall along the right abutment of the dam adjacent to the left retaining wall of the principal spillway should be repaired.

5. The riprap along the upstream slope which has experienced downslope slippage and vandalism over a period of years should be repaired. This repair work would consist of the placement of equivalent size riprap along the top of the dam.

6. The downstream wet, marshy zones should be monitored annually.

7. The reservoir should be checked annually for silt accumulations which would affect the flood storage capacity of the reservoir.

b. Operation and Maintenance Procedures. Because of the location of the dam upstream from a populated area, a formal procedure of observation and warning during periods of high precipitation or during a potentially hazardous condition should be developed and implemented. The Owner should also develop an operational procedure to follow in the event of an emergency and a maintenance inspection checklist developed to help insure that all critical items are inspected on a periodic basis.

APPENDIX

A

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM *Ironworks Dam*

ID # *PA 00789*

ITEM	REMARKS
AS-BUILT DRAWINGS	*None. Only 13 design drawings which included: stream control, spillway, plan and profile, control tower section, embankment section, topographic plan, location plan, and general plans.*
REGIONAL VICINITY MAP	*Plan A-788, No. 13815, dated 2/6/40 entitled "General Plan of Reservoir".*
CONSTRUCTION HISTORY	*Nine miscellaneous "Progress Reports" by various dam engineers from 1941 through 1942. Data is limited*
TYPICAL SECTIONS OF DAM	*Design Drawings with typical section of dam, Drawing A-811, No. 14257 dated 2/27/41.*
OUTLETS - PLAN DETAILS CONSTRAINTS	*This data (design) was presented in drawings:* *A-812 #14258, February 27, 1941* *A-814 #14260, February 27, 1941* *A-815 #14261, February 27, 1941*
DISCHARGE RATINGS	*None*
RAINFALL/RESERVOIR RECORDS	*None*

ITEM	REMARKS
DESIGN REPORTS	1) *Construction Specifications (3 pages), dated March 7, 1938* 2) *Construction Contract, dated March 7, 1938* 3) *Construction Permit, dated March 5, 1938, specifying a maximum 1 cfs rate at all times downstream*
GEOLOGY REPORTS	*"Geological Investigation of the Ironworks Creek Dam and Reservoir for Philadelphia Suburban Water Company", by Lawrence Whitcomb, Ph.D.*
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	*None available.*
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	*Reference was made to these items and boring locations were presented in the design drawings but results could not be located.*
POST-CONSTRUCTION SURVEYS OF DAM	*None*
BORROW SOURCES	*Borrow sources were located on design drawings but no records were found confirming their use.*

ITEM	REMARKS
MONITORING SYSTEMS	*None*
MODIFICATIONS	*None known.*
HIGH POOL RECORDS	*None available from DER files but some high pool records were received from the Philadelphia Suburban Water Company.*
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	*Woodward-Clyde Consultants performed a "Dam Safety Evaluation" and issued a report on July 30, 1976.*
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	*No accidents known.*
MAINTENANCE OPERATION RECORDS	*None available.*

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	*These sections are presented on the design drawings.*
OPERATING EQUIPMENT PLANS & DETAILS	*No plans available*
DISCHARGE RECORDS	*Discharge records from 1912 to 1936 by the U.S. Department of Interior, U.S. Geological Society, for Neshaminy Creek were in DER files. Current records are being maintained 3/4-mile downstream on the Neshaminy Creek at State Highway 213.*
REPORTS	*1) "Report Upon the Application of the Philadelphia Suburban Water Company" to construct Ironworks Dam, dated 5 March 1938.* *2) Seven page legal brief in support of dam by Francis W. Sullivan, Attorney for the Philadelphia Suburban Water Company.*
PHOTOGRAPHS	*39 black & white construction photographs were in DER files. Shows grout curtain pipes, core wall and rock foundation which appears to be brush cleaned and well prepared.*

APPENDIX

B

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam *Ironworks Dam* County *Bucks* State *Pennsylvania* National ID # *PA 00789*

Type of Dam *Rolled earth with concrete core wall* Hazard Category *I (High)*

Date(s) Inspection *June 6, 1978* Weather *Clear and warm* Temperature *65-70° F*

Pool Elevation at Time of Inspection *132.1* M.S.L. Tailwater at Time of Inspection *80.0* M.S.L.

Inspection Personnel:

Mary Beck (Hydrologist) *Vince McKeever (Hydrologist)*

John Boschuk, Jr. (Geotechnical/Civil) *Ray Lambert (Geologist)*

John H. Frederick, Jr. (Geotechnical)

John Boschuk, Jr. Recorder

Remarks:

Mr. Thomas Keily was on site from the Philadelphia Suburban Water Company and supplied pertinent information.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	*N/A*	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	*N/A*	
DRAINS	*N/A*	
WATER PASSAGES	*N/A*	
FOUNDATION	*N/A*	

CONCRETE/MASONRY DAMS

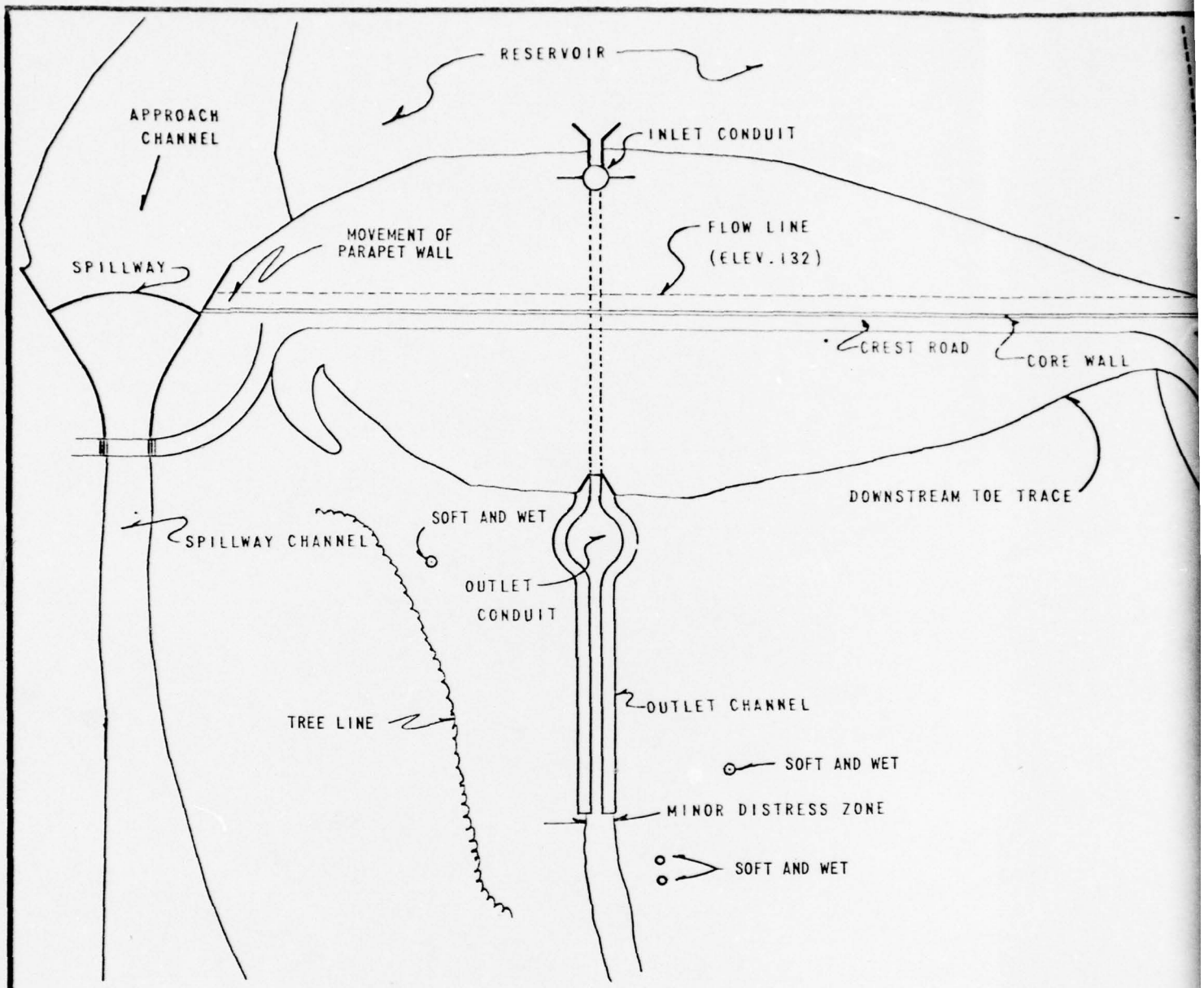
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	*N/A*	
STRUCTURAL CRACKING	*N/A*	
VERTICAL AND HORIZONTAL ALIGNMENT	*N/A*	
MONOLITH JOINTS	*N/A*	
CONSTRUCTION JOINTS	*N/A*	

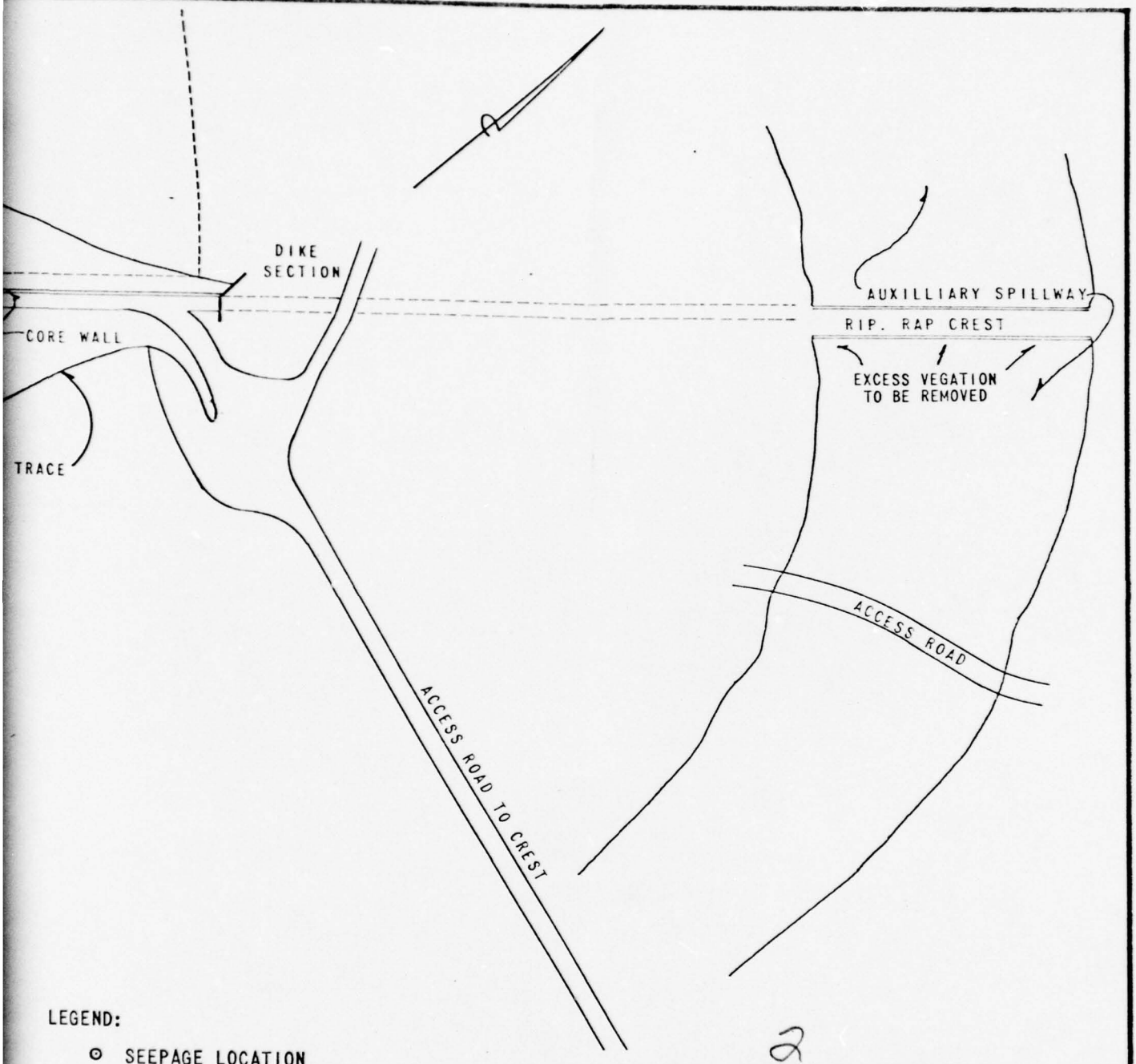
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	*None observed on the crest or slopes.*	
VEGETATION	*All trees and woody vegetation should be removed from the slopes.*	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	*None observed.*	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	*No unusual movements downstream but slope movement was observed upstream as can be seen when comparing photos 7 and 8 of Appendix D. It appears that the riprap is creeping down slope and should be restored to design elevation.*	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	*No unusual movements of the embankment were observed, but the parapet wall along the crest has localized movement of approximately 4 inches. A 30 foot section of the parapet wall next to the right abutment appears to have rotated out resulting in 4 inches of movement at the spillway. See photos 10 and 11, and sketch page 4a. The exact cause could not be ascertained but it is not impossible that freeze-thaw cycles could have precipitated the movement. No signs of impact were found that could have caused movement.*	
RIPRAP FAILURES	*As previously stated, creeping downward movement of the riprap was observed which ranged from a few inches to almost 2 feet.*	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	*Nothing unusual observed.*	
ANY NOTICEABLE SEEPAGE	*None on the embankment but seepage was observed beyond the downstream toe on both sides of the outlet discharge channel. These seeps are located as shown on sheet 5a. Water was not flowing from the seeps but the areas were soft and wet.*	
STAFF GAGE AND RECORDER	*None.*	
DRAINS	*None observed.*	


RESERVOIR
APPROACH CHANNEL
INLET CONDUIT
MOVEMENT OF PARAPET WALL
FLOW LINE (ELEV. 132)
SPILLWAY
CREST ROAD
CORE WALL
DOWNSTREAM TOE TRACE
SOFT AND WET
SPILLWAY CHANNEL
OUTLET CONDUIT
TREE LINE
OUTLET CHANNEL
SOFT AND WET
MINOR DISTRESS ZONE
SOFT AND WET
LEGEND:
SEEPA
NOTE: THE A
WET W
SEEPA
0 50 100
SCALE-FEET



LEGEND:

⊙ SEEPAGE LOCATION

NOTE: THE AREAS WERE SOFT AND WET WITHOUT ANY PERCEIVABLE SEEPAGE

2

SEEPAGE LOCATION PLAN
IRON WORKS DAM

NAT. ID NO.PA.00789 BUCKS COUNTY

SHEET 5a OF 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	*The concrete intake tower, pipes and valves appeared to be in good condition. There was very little spalling observed and minor leaks were limited to the joints within the outlet tunnel. The seepage noted had not increased since the inspection performed by the Owner's representative on February 6, 1973.*	
INTAKE STRUCTURE	*All pipes were observed to be in good condition with no leakage observed. The tower structure was observed to be in good condition. Although the tower and dam crest have provisions for a bridge connecting these features it was never constructed.*	
OUTLET STRUCTURE	*The cast iron water supply and drainage pipes appeared to be in good condition.*	
OUTLET CHANNEL	*Outlet channel and aerator appeared to be in good condition and functioning as designed.*	
WATER CONTROL VALVE	*The 8 inch emergency drain valve was exercised and water was heard flowing through the system. Similarly, the principal water supply pipe valve at the base of the intake tower was exercised and appeared to function properly. All valves were clean, painted, and greased.*	

UNGATED SPILLWAY

Principal Spillway

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	*The spillway consists of a concrete ogee weir faced with masonry. The spillway is a 110 foot circular arc at elevation 132. See photo 1 . The spillway appears to be in good condition.*	
APPROACH CHANNEL	*The channel is excavated in the right abutment and was under water. A visual inspection could not be made.*	
DISCHARGE CHANNEL	*The discharge channel consists of a stilling pool immediately below the primary spillway with an overflow weir. Water flows over the weir and discharges into a mortar and stone channel which discharges into the natural streambed. The discharge system appears to be in good condition. The drain pipe embedded in the overflow weir was functioning.*	
BRIDGE AND PIERS	*A service road bridge is constructed over the spillway (see photo 2). The bridge span is approximately 30 feet and there is approximately 19 feet between the channel bottom and the underside of the bridge. There is a chance that debris could block the spillway during an extreme event. The bridge was in a good state of repair. The original bridge was wood and records provided by Phila. Suburban Water Co. indicated that the wood bridge was replaced in 1950 with the present steel structure.*	

UNGATED SPILLWAY

Emergency Spillway

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	*A concrete sill 202 feet long with riprap on the downstream side appears to be stable. Large trees are growing at the sill and within the riprap zone on both sides of the sill which should be removed. See sheet 5a. The riprap-control section is in good condition.*	
APPROACH CHANNEL	*The approach channel near the reservoir is wet and a grove of trees has grown up. Although it would be desirable to remove the trees, it is not necessary. Trees growing in the channel near the crest should be removed. The channel bottom is densely vegetated and appears stable. This wet zone is as expected because the approach slope is very shallow and small fluctuations in the reservoir wet several feet of the channel.*	
DISCHARGE CHANNEL	*The channel is approximately 270 feet long with a 1 % slope grading to a steeper overfall. Trees growing in the channel should be removed. The channel is densely vegetated and appears to be stable.*	
BRIDGE, PIERS AND CHANNEL BLOCKAGE	*None. It is highly unlikely that debris would collect in the channel during an extreme event once the trees are removed.*	
GATES AND OPERATION EQUIPMENT	*None.*	

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	*None.*	
OBSERVATION WELLS	*None.*	
WEIRS	*None.*	
PIEZOMETERS	*None.*	
OTHER	*None.*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	*Reservoir slopes are moderate and stable. Grass and trees of mixed variety are growing to the water's edge.*	
SEDIMENTATION	*A considerable amount of sediment is entering the reservoir at the upper end. This has no significant effect on the available flood storage but has affected the water supply storage capacity of the reservoir.*	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	*Immediately downstream of the dam the channel has a stoney bottom, meanders, and trees have fallen over in places. The flood plain is about 500 feet wide and is tree and brush covered. About 2000 feet downstream of the dam the stream passes through a 45 foot by 8 foot bridge under Chiquapin Road. About 3000 feet downstream, Ironworks Creek joins with Mill Creek and passes through a twin stone arch bridge under Holland Road. Dense vegetation and poison ivy prevents a detailed inspection of the channel between the riprap channel section and the first bridge downstream of the dam.*	
SLOPES	*The valley gradient is about 1 %. The channel banks are shallow with steep slopes from the top of the bank to the channel bottom. Some bank erosion can be observed where surface runoff concentrates before entering the stream.*	
APPROXIMATE NO. OF HOMES AND POPULATION	*Several houses and businesses upstream and downstream of Holland Road are built on the flood plain and are subject to flooding. Approximately 2.3 miles downstream of the dam, Ironworks Creek enters the Neshaminy Creek where residential dwelling density increases significantly.*	

APPENDIX

C

IRONWORKS DAM
CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: *Approx. 50% residential; remaining mostly open/ farm*

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): *132.0 ft. (1995 Ac-Ft)*

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): *136- Crest Emergency Spillway*

ELEVATION MAXIMUM DESIGN POOL: *Elev. 140 (1 foot above top of dam) as per applic. report*

ELEVATION TOP DAM: *139.0 embankment, 142.0 parapet wall*

SPILLWAYS:

a. Elevation *Principal, 132.0; Emergency, 136.0*

b. Type *Principal, ogee weir; Emergency, earth/ rock channel*

c. Width *Principal, 110 feet; Emergency, 202 feet*

d. Length *Principal, 122 ft. to channel; Emergency, 600 ft. along centerline*

e. Location Spillover *Principal, right abutment; Emergency, left abutment*

f. Number and Type of Gates *None*

OUTLET WORKS: (WATER SUPPLY TOWER)

a. Type *Intake tower*

b. Location *465 ft. from left abutment*

c. Entrance inverts *Skimming weir 132; top pipe 121±; mid pipe 106±*

d. Exit inverts *Aerator outlets at 102.2 ft.*

e. Emergency draindown facilities *8 inch pipe at base of tower*

HYDROMETEOROLOGICAL GAGES:

a. Type *None at dam; Gage station on Neshaminy Creek*

b. Location *1.6 miles downstream on Neshaminy Creek*

c. Records *All records are maintained at the Neshaminy Station*

MAXIMUM NON-DAMAGING DISCHARGE: *5,000 cfs*

DAM SAFETY ANALYSIS
HYDROLOGIC/HYDRAULIC DATA

Date: 6/19/78
By: MFB
Sheet: 2 of 6

DAM Ironworks Dam Nat. ID No. PA 00789 DER No. 9-137

	ITEM/UNITS	Permit/Design Files (A)	Calc. from Files/Other (B)	Calc. from Observations (C)
1.	Min. Crest Elev., ft.			
2.	Freeboard, ft.			
3.	Spillway(1) Crest Elev, ft.		192 ft	
3a.	Secondary(2) Crest Elev, ft.		196 ft	
4.	Max. Pool Elev., ft.			
5.	Max. Outflow(3), cfs	13,900 cfs*	15,700 cfs*	
6.	Drainage Area, mi^2	6.4 mi^2		5.7 mi^2
7.	Max. Inflow(4), cfs		18,460 cfs	16,826 cfs
8.	Reservoir Surf. Area,	172 Ac.		170 Ac
9.	Flood Storage(5), ft^3			
10.	Inflow Volume, ft^3			

Reference all figures by number or calculation on attached sheets:

Example: 3A - Drawing No. xxx by J. Doe, Engr., in State File No. yyyy.

NOTES:

(1) Main emergency spillway

(2) Secondary ungated spillway.

(3) At maximum pool, with freeboard, ungated spillways only.

(4) For B, C, use PMF.

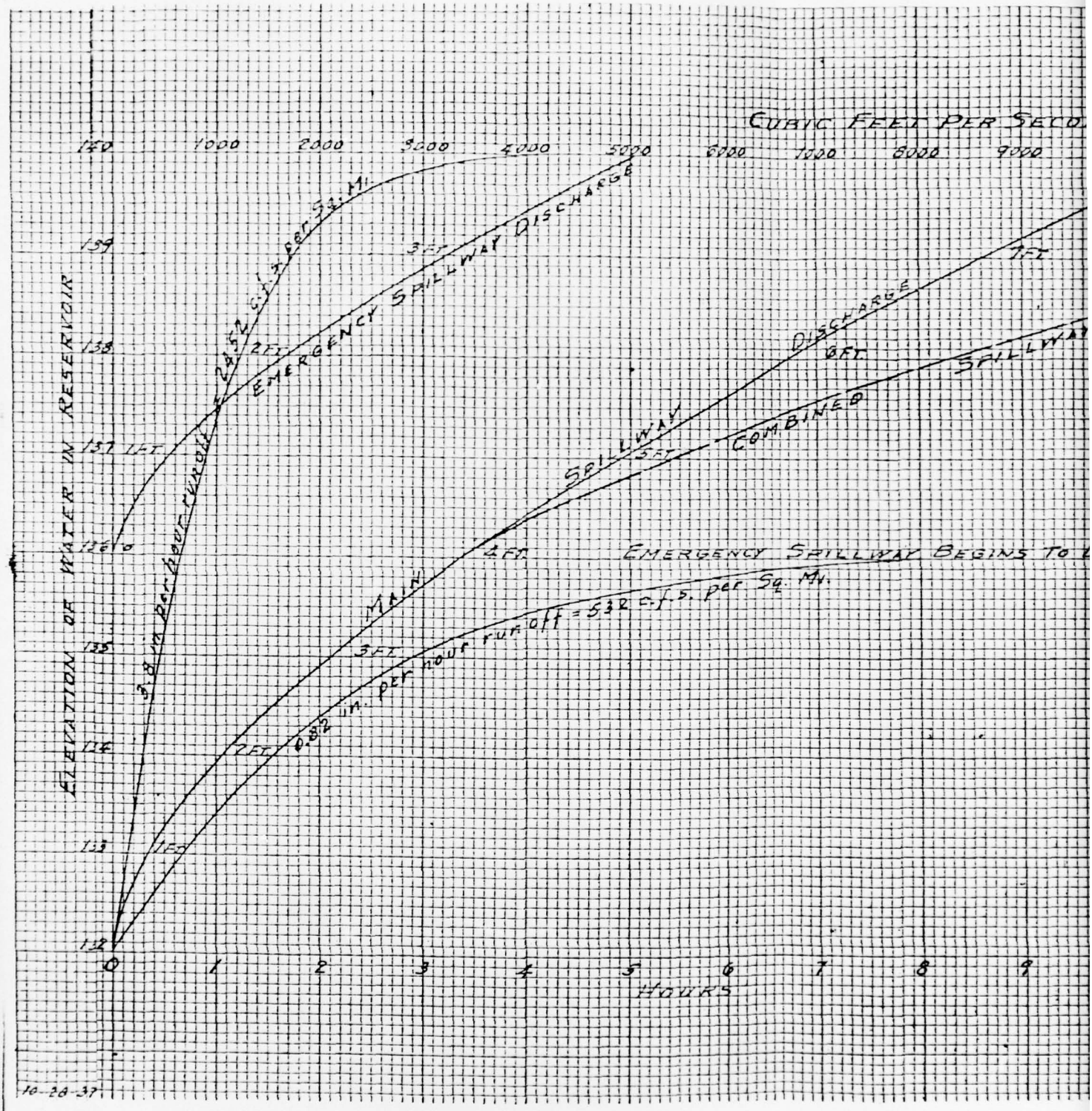
(5) Between lowest ungated spillway and maximum pool.

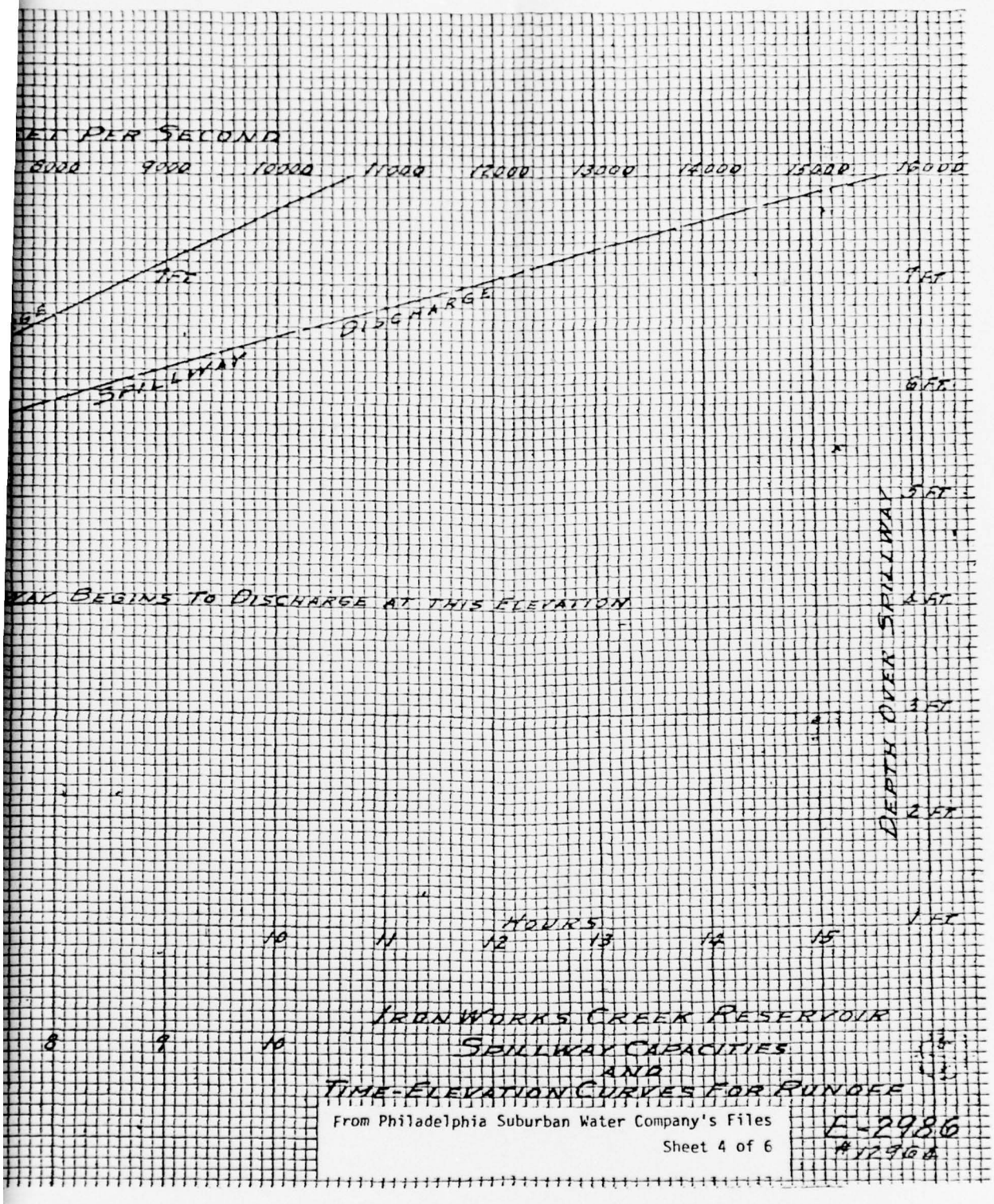
* Reservoir Water Elev. at 140 ft

Date: 6/19/78
By: MFB
Sheet: 3 of 6

HYDROLOGIC/HYDRAULIC CALCULATIONS (cont.)

Item (from	Source
5A, 6A, 8A	Application Report dated June 30, 1978
3B, 3aB	PSWCo. Drawings
7B	PSWCo Rating Curve, E-2986
5B	Woodward-Clyde Report, July 30, 1976 (calculations on file at PSWCo)
7C	See Sheet
6C, 8C	USGS Maps Langhorne (1973) Hatboro (1973)


CUBIC FEET PER SECO
1000
2000
3000
4000
5000
6000
7000
8000
9000
ELEVATION OF WATER IN RESERVOIR
139
138
137 1/2 FT.
136
135
134
133
132
0
1
2
3
4
5
6
7
8
9
HOURS
EMERGENCY SPILLWAY DISCHARGE
2 1/2 C.F.S. per Sq. Mi.
2 FT.
3 FT.
MAIN SPILLWAY DISCHARGE
7 FT.
6 FT.
SPILLWAY
COMBINED
3 FT.
2 FT.
EMERGENCY SPILLWAY BEGINS TO
MAIN
3 FT.
2 FT.
0.82 IN. PER HOUR RUN-OFF = 53 R.C.F.S. per Sq. Mi.
5.8 IN. PER HOUR RUN-OFF
10-20-37

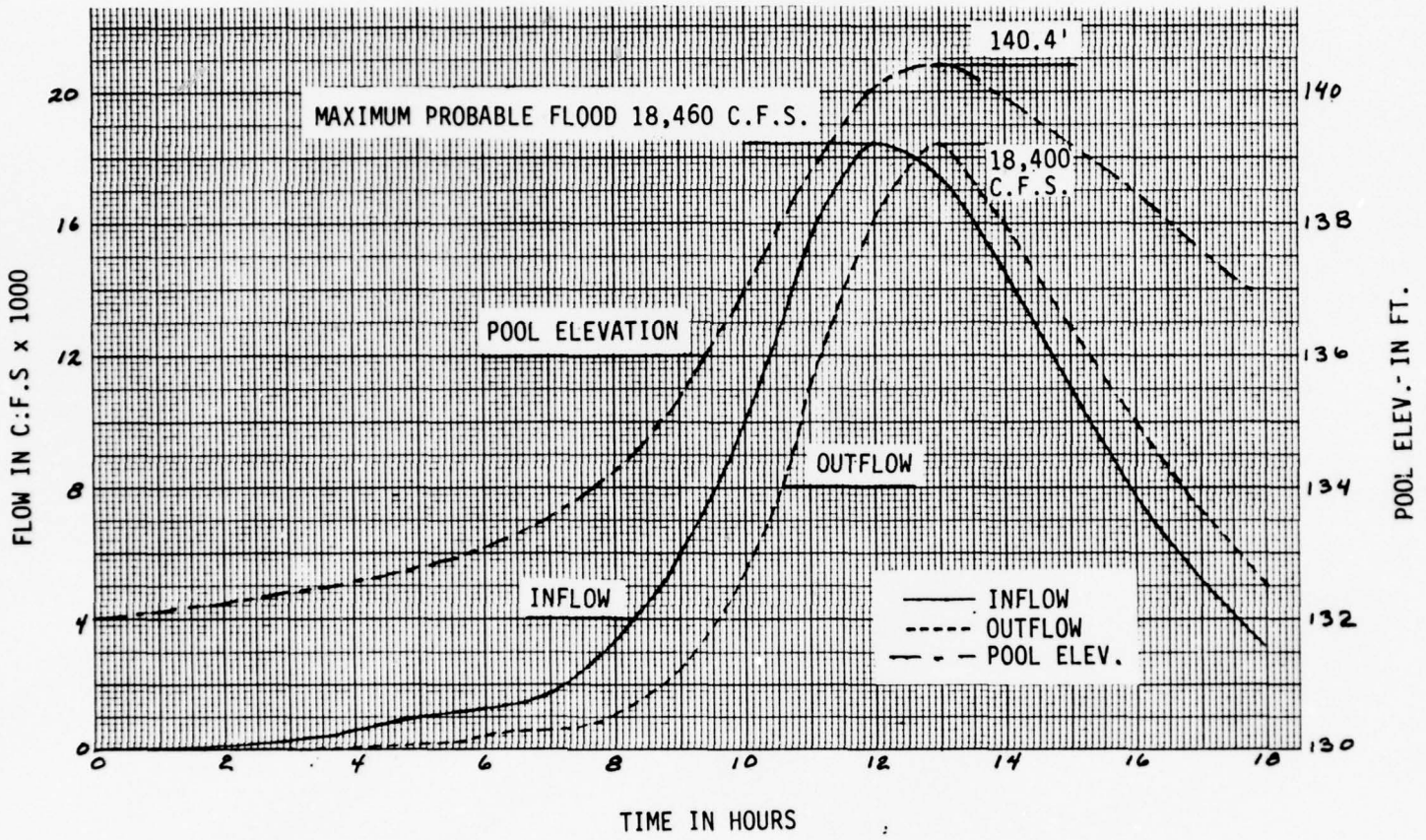


IRONWORKS CREEK RESERVOIR
SPILLWAY CAPACITIES
AND
TIME-ELEVATION CURVES FOR RUNOFF

From Philadelphia Suburban Water Company's Files
Sheet 4 of 6

E-2986
#11966

PMF DESIGN HYDROGRAPHS IRONWORKS RESERVOIR



BY MFD DATE 6/19/18 SUBJECT Ironworks Dam Hydrology / Hydraulics SHEET 6 OF 6

CHKD. BY JMB DATE 7/9/18 JOB No

Calculated PMF Peak Inflow
(calculations on file at PSWCo.)

Based on drainage area of 6.4 sq. miles

Q_1 = 18460 cfs

Measured drainage area is 5.7 sq. miles

$$\left(\frac{5.7}{6.4}\right)^{0.8} 18460$$

Q = 16,826 cfs

BY MFB DATE 7/13/78 SUBJECT Ironworks Dam SHEET 6a OF
CHKD. BY RHC DATE 7/19/78 Hydrology / Hydraulics JOB No.

Estimate Flow Through Bridge on Chiquapin Road, 2000 ft. Downstream From Dam

Measured Bridge Opening 45 ft x 8 ft
Distance Between Bottom of Bridge and Roadway = 2 ± ft
S_w = 0.0089 from USGS Map (Langhorne)

n estimated to be 0.03

Channel Downstream From Bridge
Bottom Width b = 55 ft
Ave. Side Slopes = 4:1
Assume depth of water downstream of bridge can be determined from Mannings Equation

Flow through bridge computed by orfice flow equation,

$$q = CA\sqrt{2g\Delta h}$$ Ref. National Engineering Handbook, Section 4 Eq. 14-25

where Δh is the difference in water elevation upstream and downstream of bridge

C ranges from 0.7 to 0.9, use 0.8 (p. 14-45)
A = area under bridge

Assume Q = 5000 cfs

$$5000 = 0.8 \cdot 360\sqrt{2g\Delta h}$$
$$\Delta h = 4.68 \text{ ft}$$

$$Q = \frac{K'}{n} b^{8/3} S^{1/2}$$ ref. King & Brater Handbook of Hydraulics

$$5000 = \frac{K'}{0.03} 55^{8/3} 0.0089^{1/2}$$
$$K' = 0.0363$$

$$D/b = 0.098 \quad D = 5.39 \text{ ft.}$$

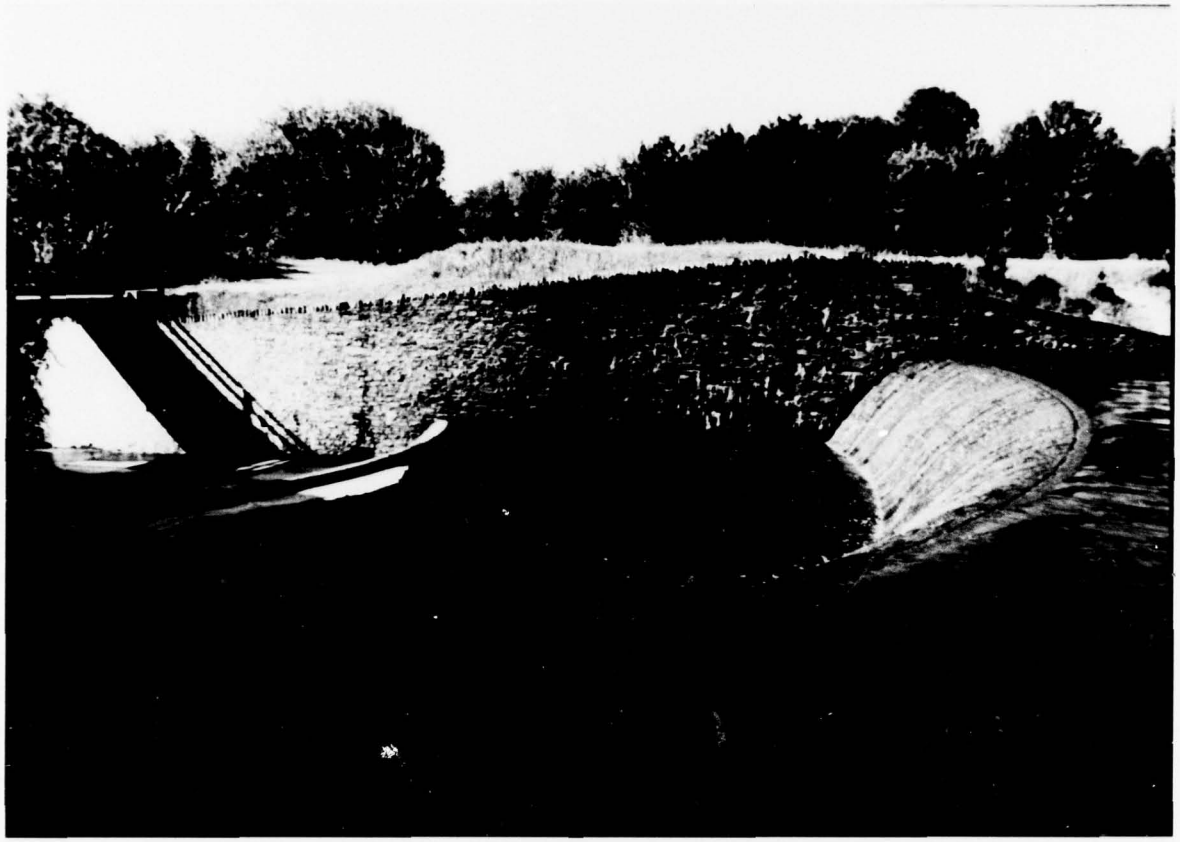
D + Δh = 5.39 + 4.68 = 10.07 ft the required upstream to overtop roadway, therefore Q = 5000 cfs

APPENDIX

D

VIEW FROM BRIDGE LOOKING UPSTREAM TOWARDS PRINCIPAL SPILLWAY, STILLING POOL AND OVERFLOW WEIR.

PHOTO NO. 1

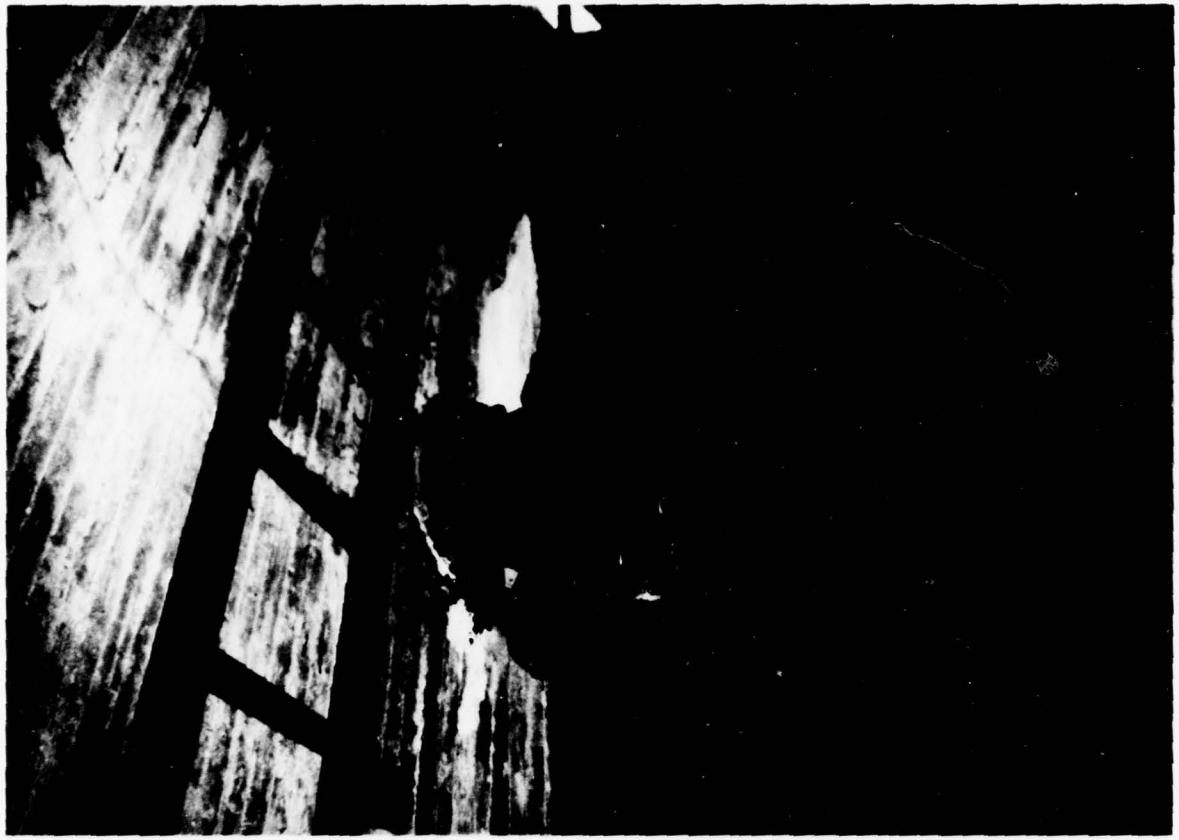


LOOKING DOWNSTREAM OVER PRINCIPAL SPILLWAY FROM RIGHT ABUTMENT (W/S) OF DAM. NOTE BRIDGE ON LEFT SIDE OF PHOTO.

PHOTO NO. 2

PHOTO TAKEN FROM BRIDGE OVER SPILLWAY LOOKING DOWNSTREAM.

PHOTO NO. 3



VIEW INSIDE INTAKE TOWER LOOKING AT INTAKE PIPE AT WALL. THE CONDITION OF PIPE SHOWN IS TYPICAL FOR ALL PIPING INSIDE THE TOWER.

PHOTO NO. 4

VIEW LOOKING FROM TOP OF DAM TOWARDS WATER SUPPLY AERATION SPILLWAY AND DOWNSTREAM CHANNEL.

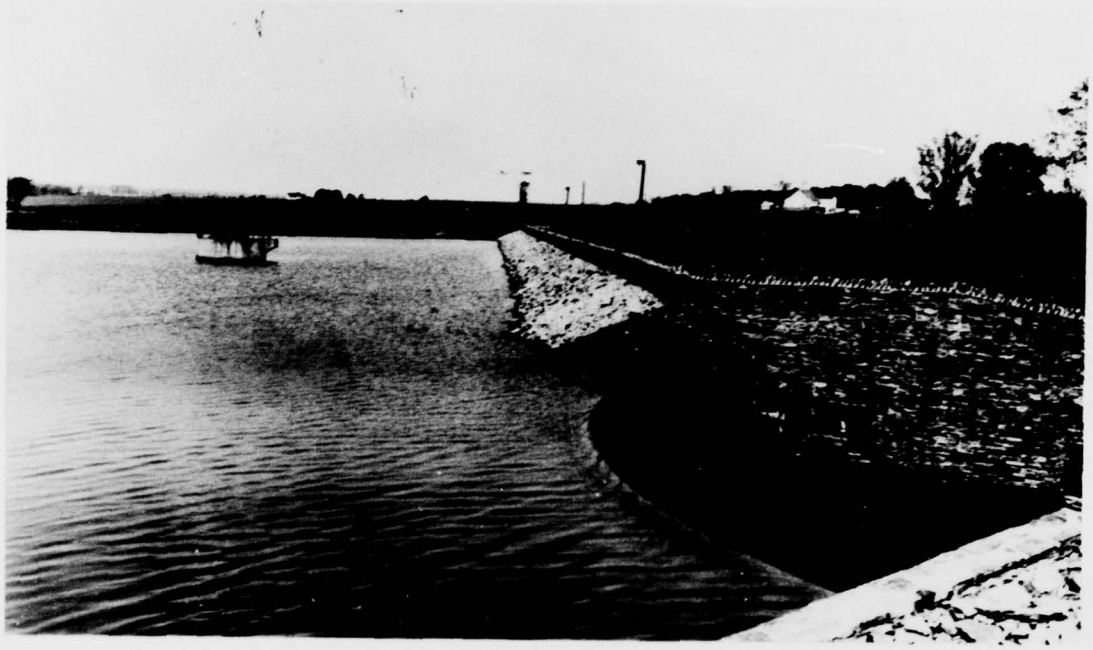
PHOTO NO. 5

VIEW LOOKING FROM RIGHT ABUTMENT OF THE EMERGENCY SPILLWAY. THE RESERVOIR IS TO THE LEFT OF THE PHOTO. NOTE THE CONCRETE SILL AND TREES GROWING IN THE SPILLWAY.

PHOTO NO. 6

PHOTO TAKEN FROM THE UPSTREAM SLOPE LOOKING TOWARDS THE CONCRETE CUTOFF WALL. NOTE SETTLEMENT. HOWEVER, SOME OF THE ROCK WAS REMOVED BY VANDALISM. COMPARE THIS WITH PHOTO 8 WHICH SHOWS ORIGINAL ELEVATION OF RIPRAP.

PHOTO NO. 7



PHOTOGRAPH SHOWS THE FINISHED RIPRAP SLOPE WHICH TERMINATES AT THE BASE OF THE PARAPET WALL. COMPARE THE FINISHED SLOPE SHOWN HERE WITH PHOTOGRAPH NO. 7 WHICH SHOWS THE SETTLEMENT OBSERVED DURING THE INSPECTION.

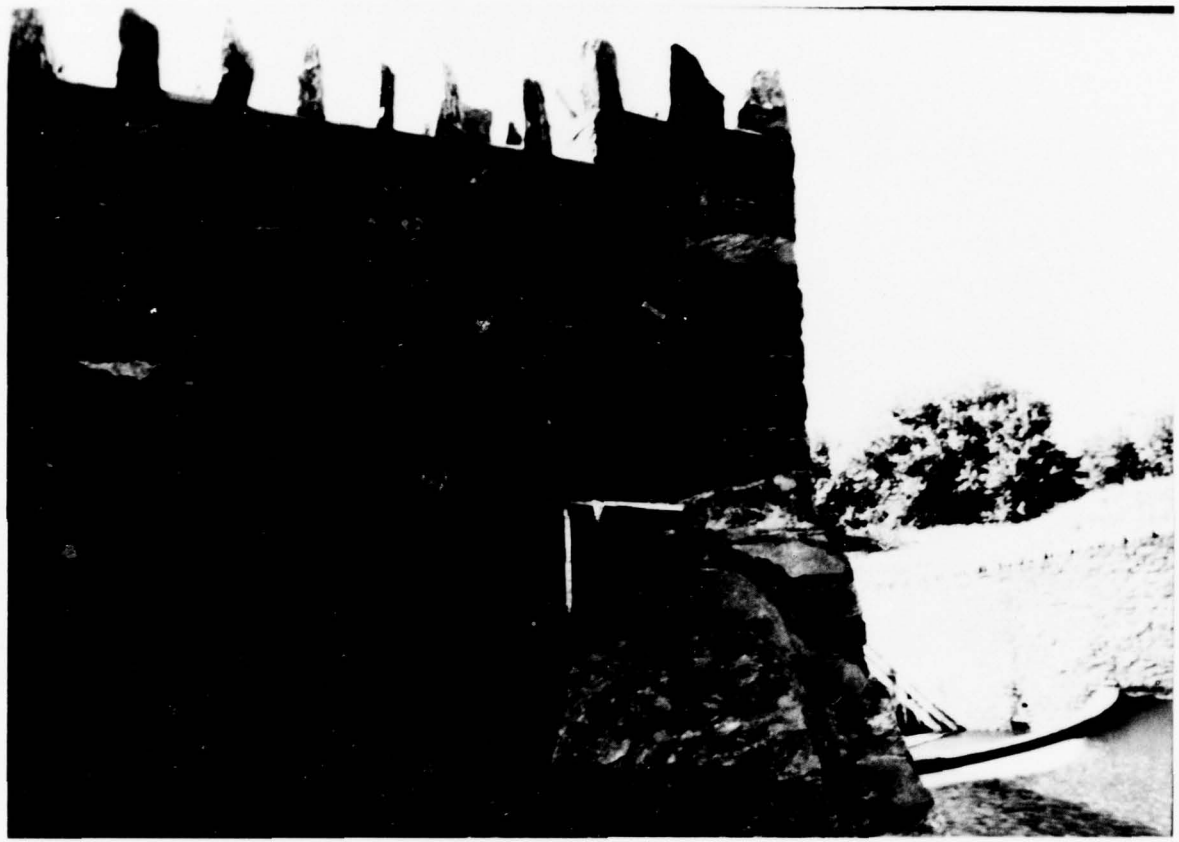
PHOTO NO. 8

CLOSE-UP VIEW OF SETTLEMENT ON THE UPSTREAM SIDE OF THE CONCRETE CUTOFF WALL. APPROXIMATELY 18 INCHES OF SETTLEMENT WAS NOTED HERE.

PHOTO NO. 9

VIEW OF MORTAR WALL MOVEMENT AT RIGHT ABUTMENT OF DAM. MAXIMUM MEASURED MOVEMENT WAS 4 INCHES. SEE PHOTO 11 FOR MORE DETAIL.

PHOTO NO. 10



VIEW SHOWS DISTRESS ON SPILLWAY CHANNEL WALL AS A RESULT OF WALL MOVEMENT ON CONCRETE CORE WALL. SEE PHOTO 10 FOR MORE DETAIL.

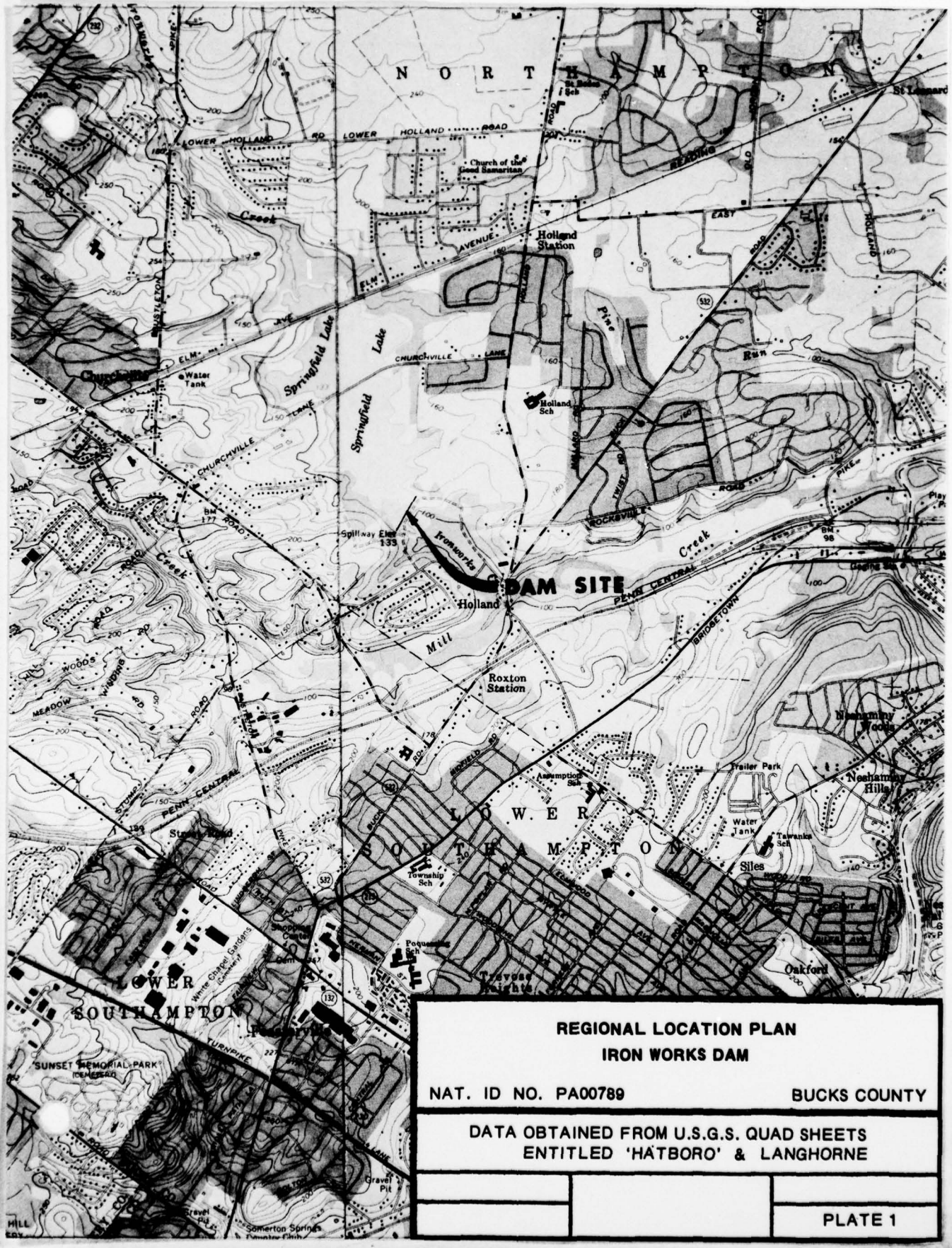
PHOTO NO. 11

VIEW FROM LEFT ABUTMENT TOWARDS DOWNSTREAM SLOPE.
NOTE DENSE VEGETATION ON SLOPE.

PHOTO NO. 12

APPENDIX

E



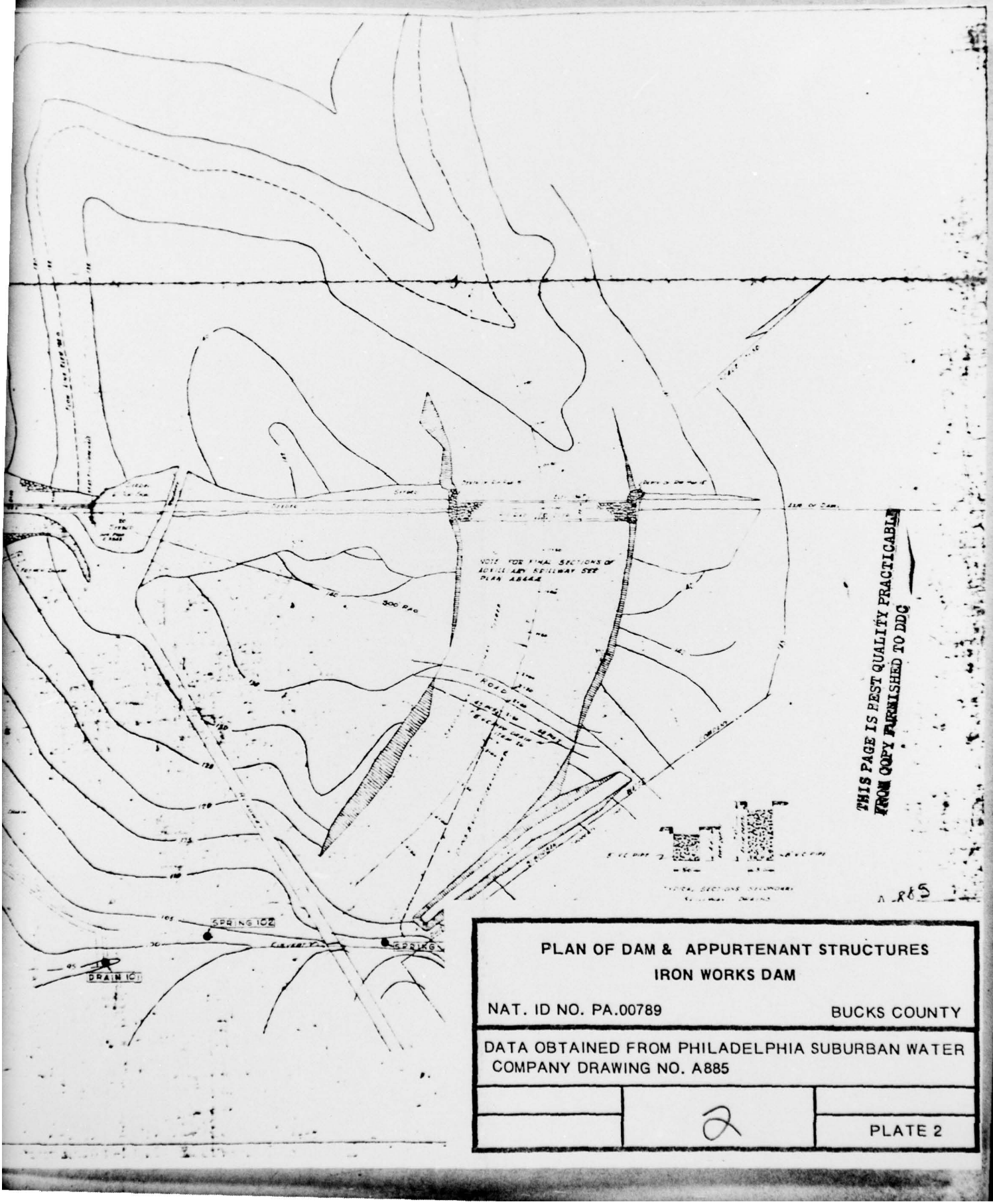
REGIONAL LOCATION PLAN
IRON WORKS DAM

NAT. ID NO. PA00789 BUCKS COUNTY

DATA OBTAINED FROM U.S.G.S. QUAD SHEETS
ENTITLED 'HATBORO' & LANGHORNE

PLATE 1


FOR FINAL SECTIONS THRU DAM SEE PLAN NO AB28
FOR FINAL CHANNEL SECTIONS SEE PLAN NO AB28 &
NOTE FOR FINAL SECTIONS THRU CONDUIT SEE PLAN NO AB30 & AB93
FOR DETAIL OF SPILLWAY CHANNEL SEE PLAN NO AB44-
FOR FINAL SECTIONS THRU CHANNEL SEE PLAN AB31-7 SHEETS
DRAIN IC1



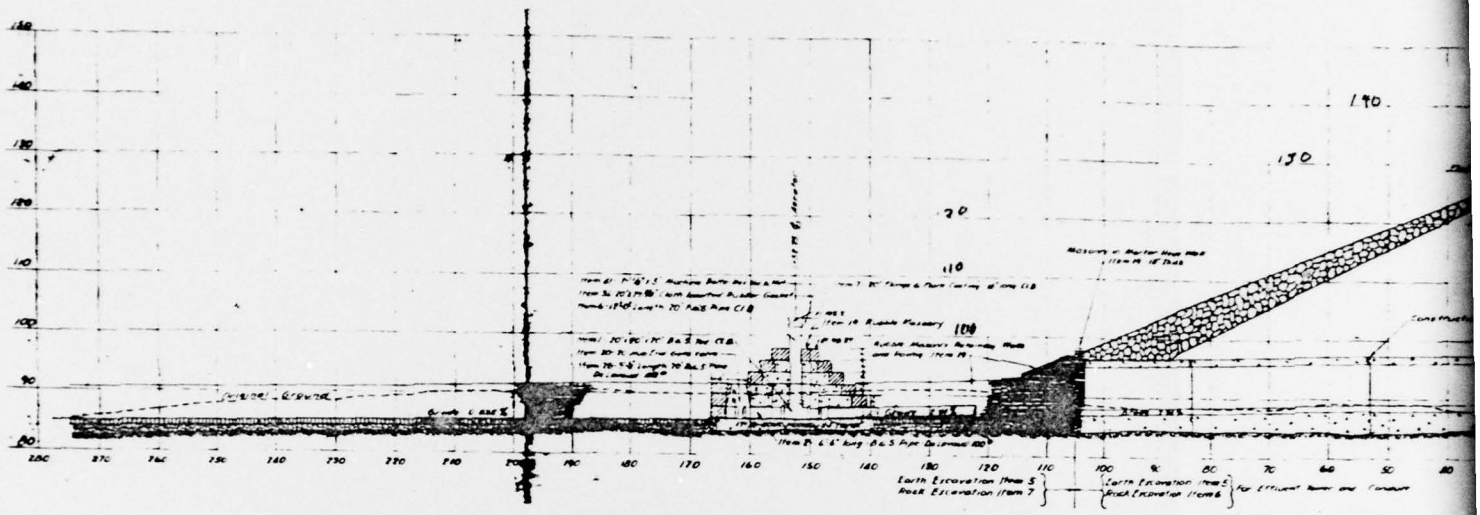
PLAN OF DAM & APPURTENANT STRUCTURES
IRON WORKS DAM

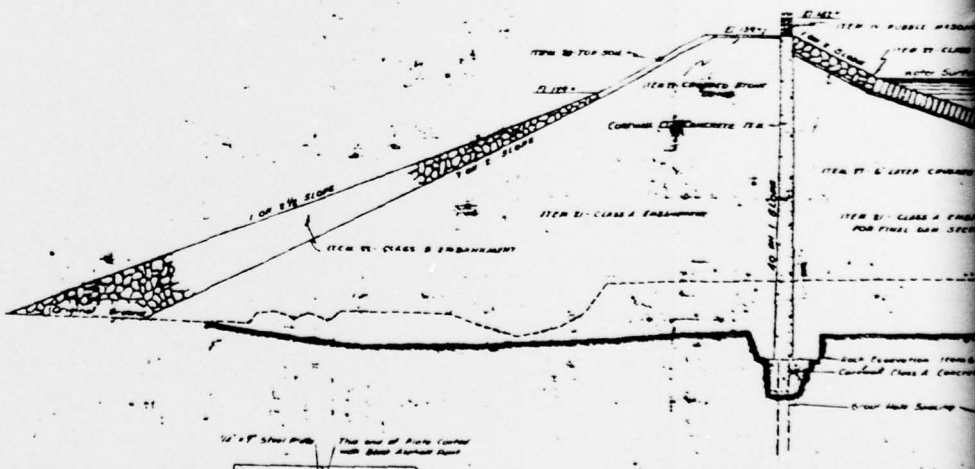
NAT. ID NO. PA.00789 BUCKS COUNTY

DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER COMPANY DRAWING NO. A885

2

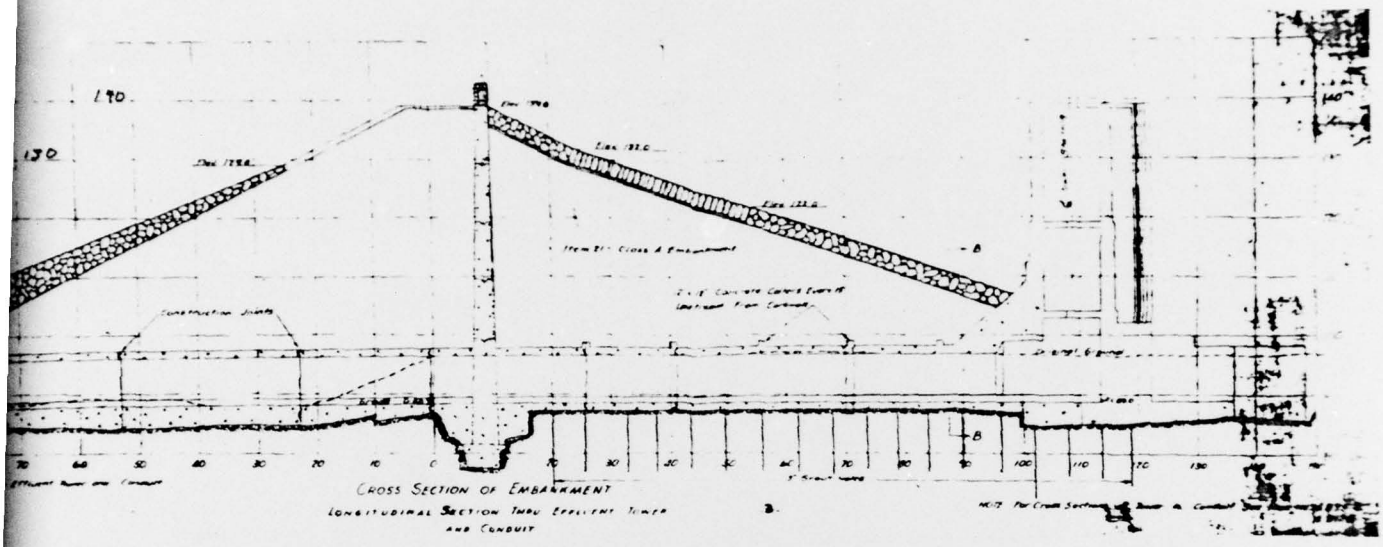
PLATE 2

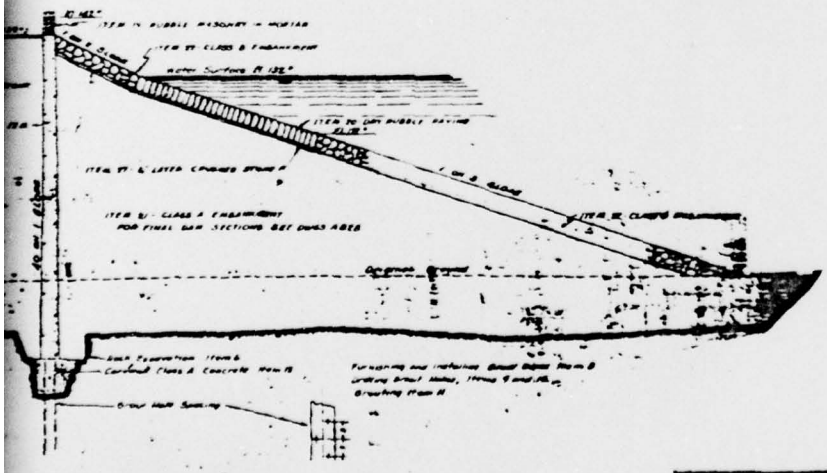




TYPICAL EMBANKMENT CROSS SECTION AT STATION 5+

SHOWING CLASSIFICATION OF MATERIALS

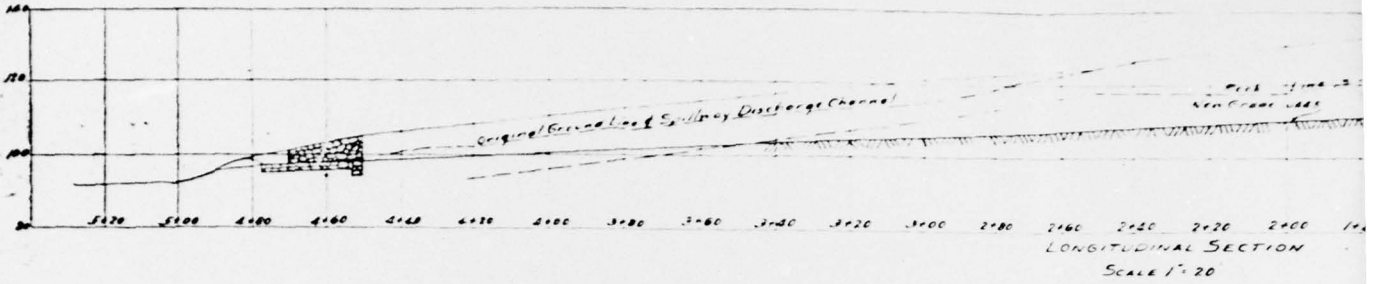


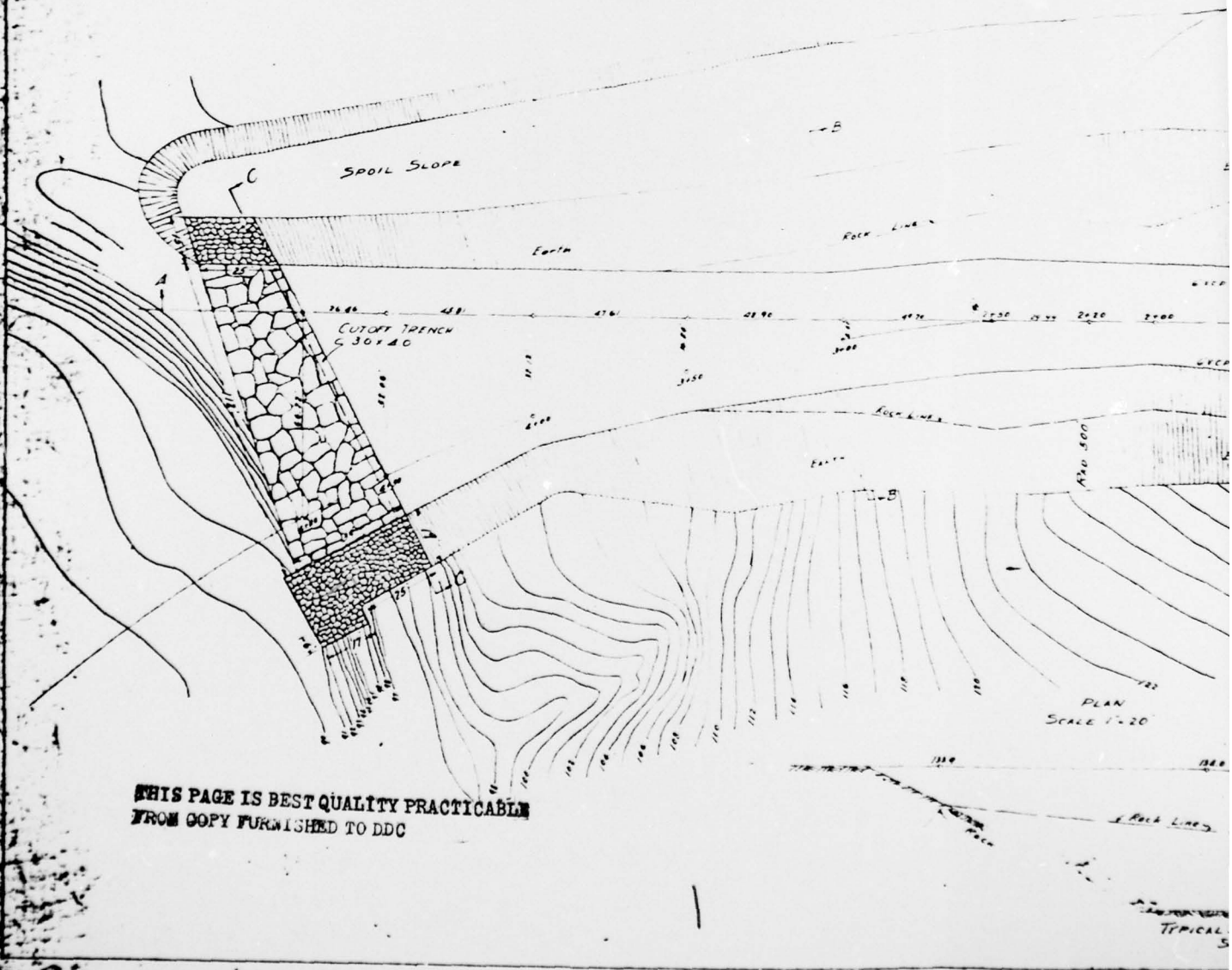


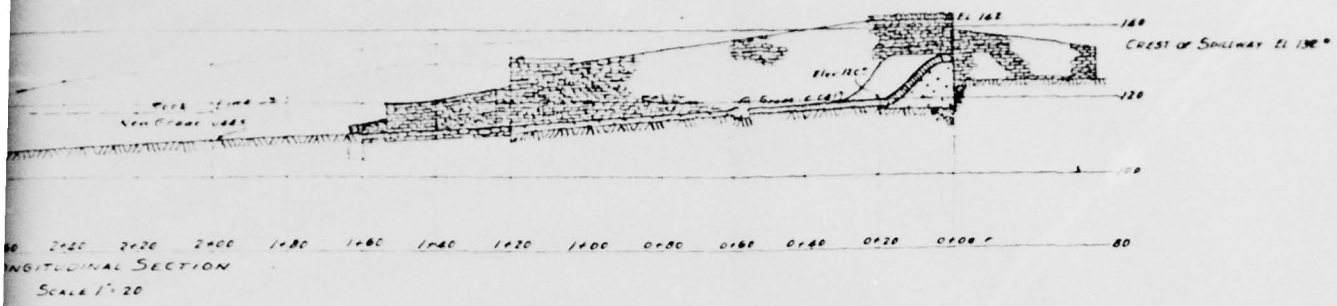
CROSS SECTION AT STATION 5+

2

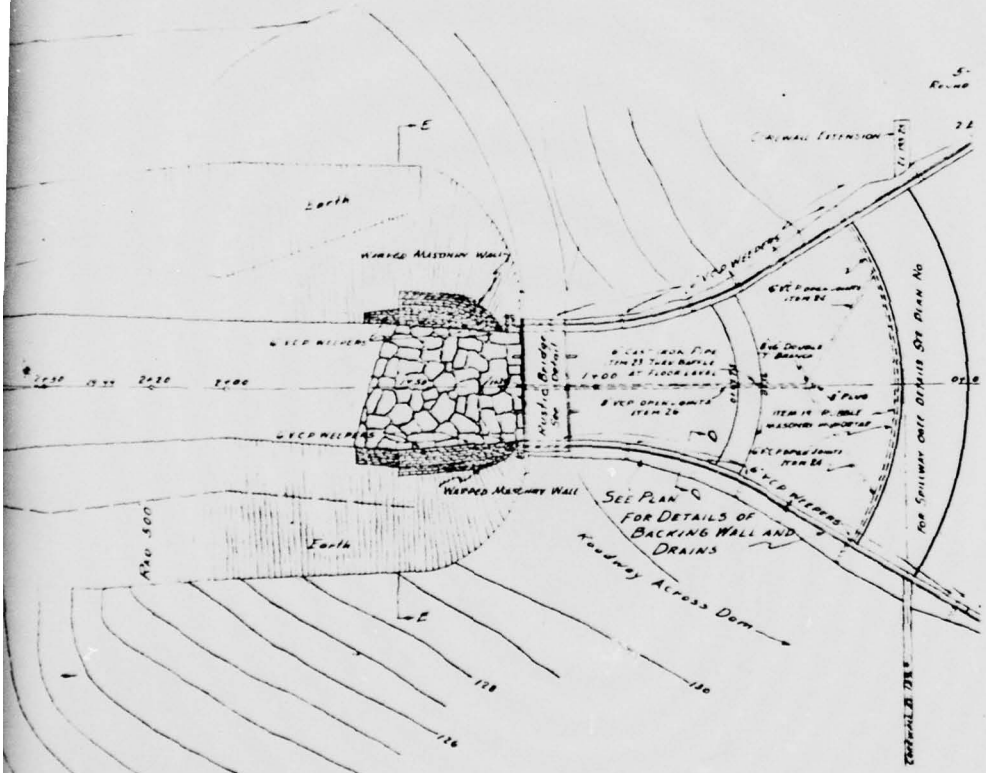
TYPICAL EMBANKMENT SECTION IRON WORKS DAM		
NAT.ID NO. PA.00789		BUCKS COUNTY
DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER COMPANY DRAWING NO. A 811-A		
		PLATE 3



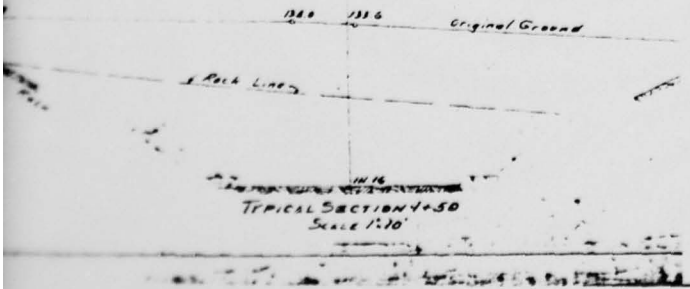




LONGITUDINAL SECTION
SCALE 1" = 20'



PLAN
SCALE 1" = 20'



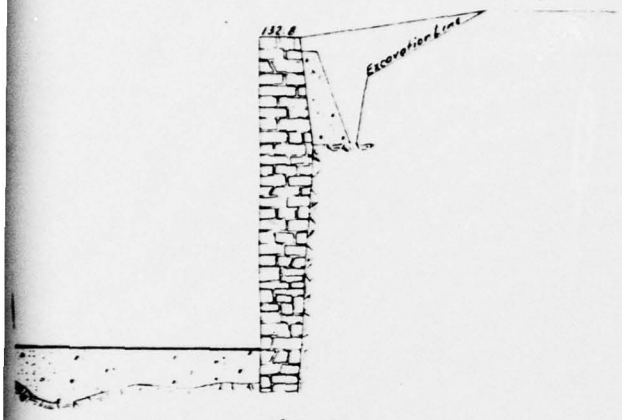
2

PLAN AND PROFILE OF PRIMARY SPILLWAY CHANNEL
IRON WORKS DAM

NAT. ID NO. PA. 00789 BUCKS COUNTY

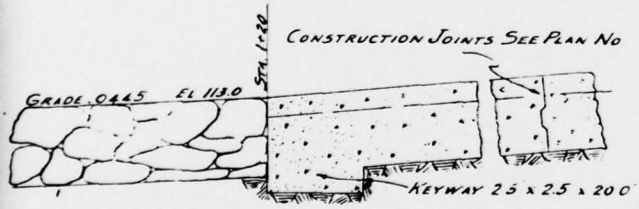
DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER COMPANY DRAWING NO. A 814-A

PLATE 4

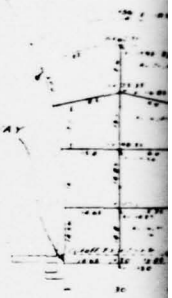


SECTION D-D (See Plan A 816-A)

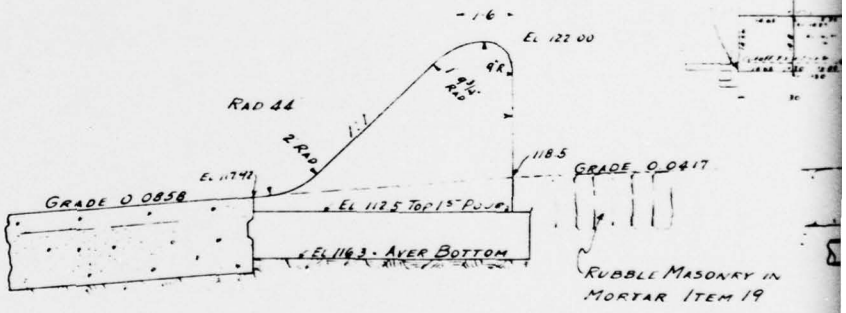
SCALE 1" = 4'

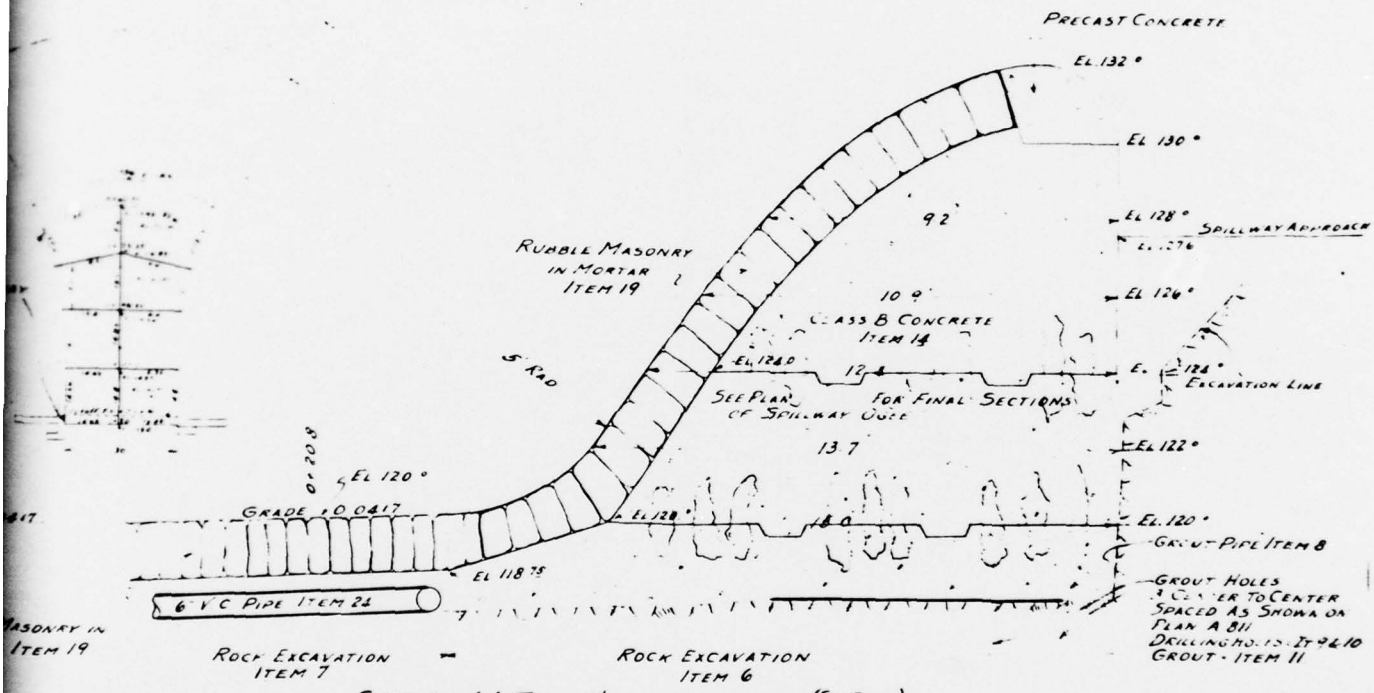


PLAN OF SPILLWAY FLOOR BELOW BAFFLE WEIR



SEE PLAN FOR FINAL SECTIONS OF SPILLWAY FLOOR ITE. 15 CLASS C CONCRETE





SECTION A-A THRU ℄ OF SPILLWAY (See Plan A 815-A)

SCALE - 1" = 2'

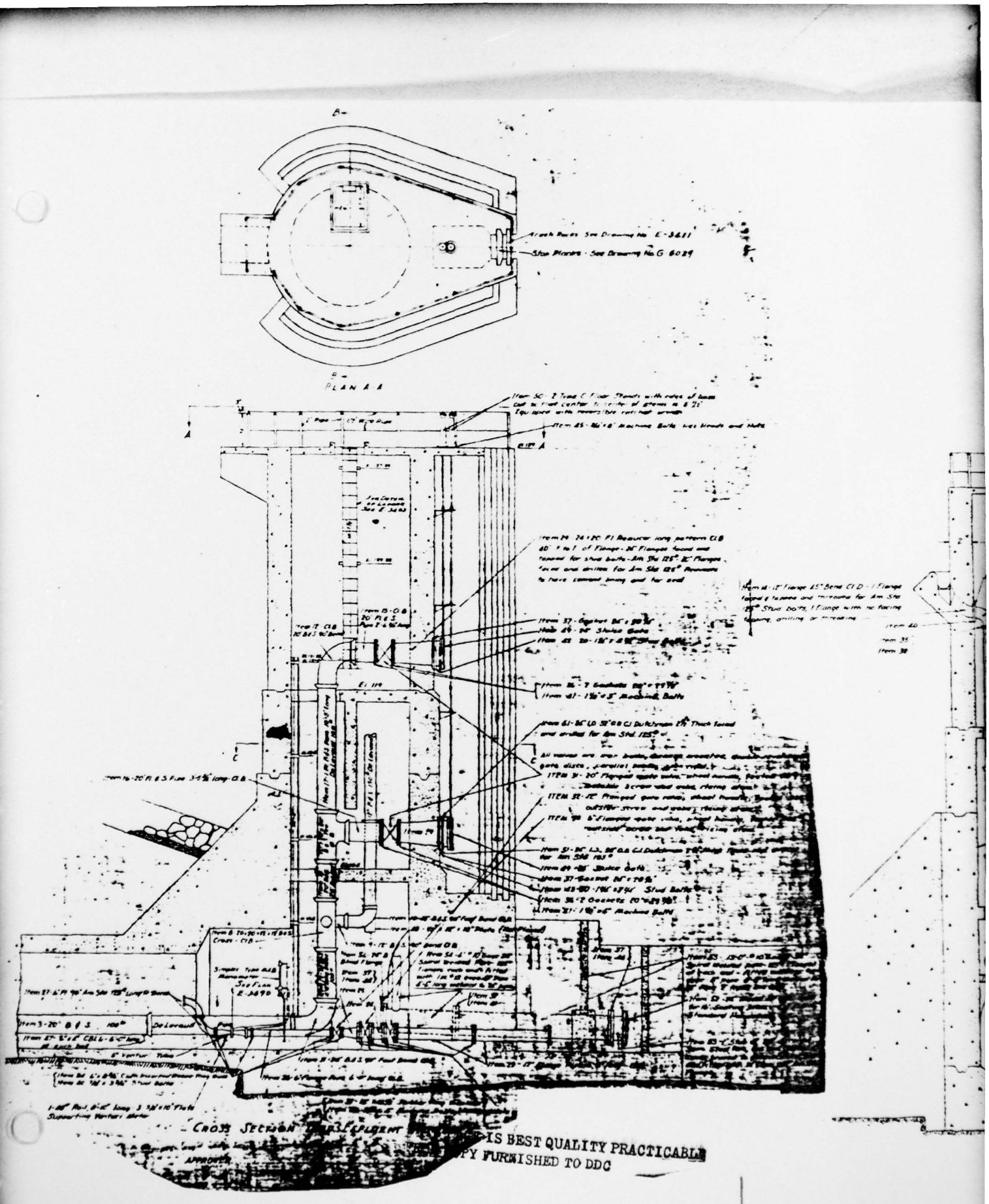
2

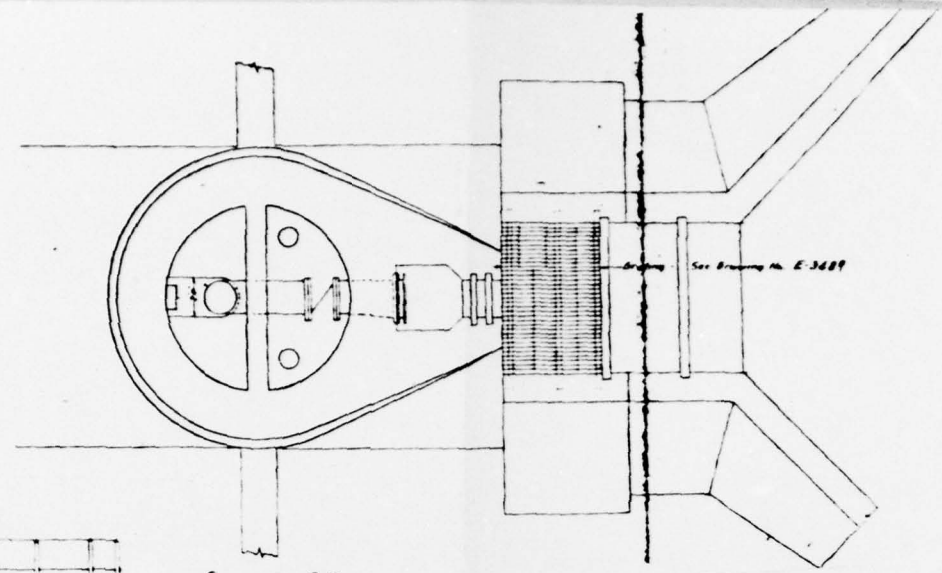
DETAILS OF PRIMARY SPILLWAY
IRON WORKS DAM

NAT. ID NO. PA.00789 BUCKS COUNTY

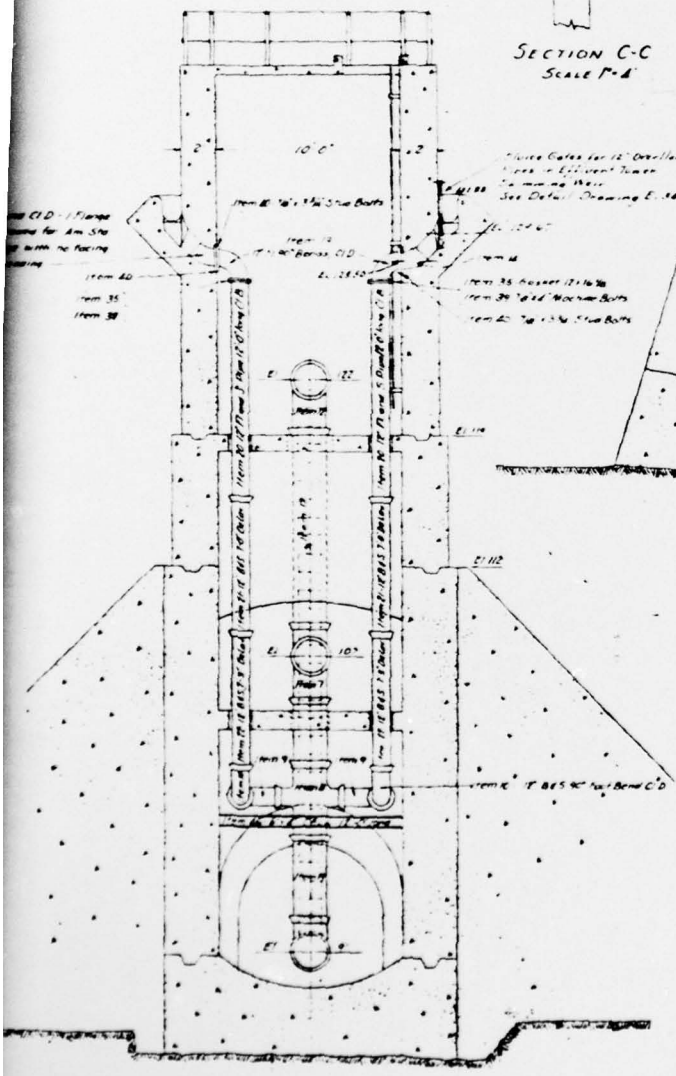
DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER COMPANY DRAWING NO. A 815-A

PLATE 5

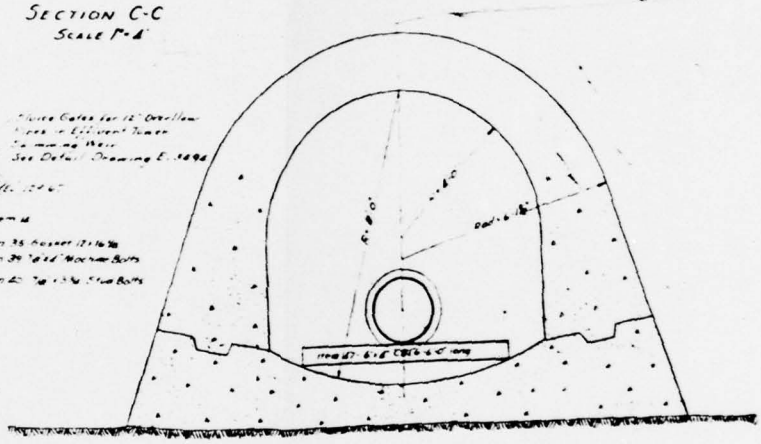




SECTION C-C
SCALE 1"=4'



SECTION B-B
SCALE 1"=4'



TYPICAL CROSS SECTION OF CONDUIT
SCALE 1"=2'

2

PLAN & PROFILES OF INTAKE TOWER
IRON WORKS DAM

NAT. ID NO. PA.00789 BUCKS COUNTY

DATA OBTAINED FROM PHILADELPHIA SUBURBAN WATER COMPANY DRAWING NO A 812-A

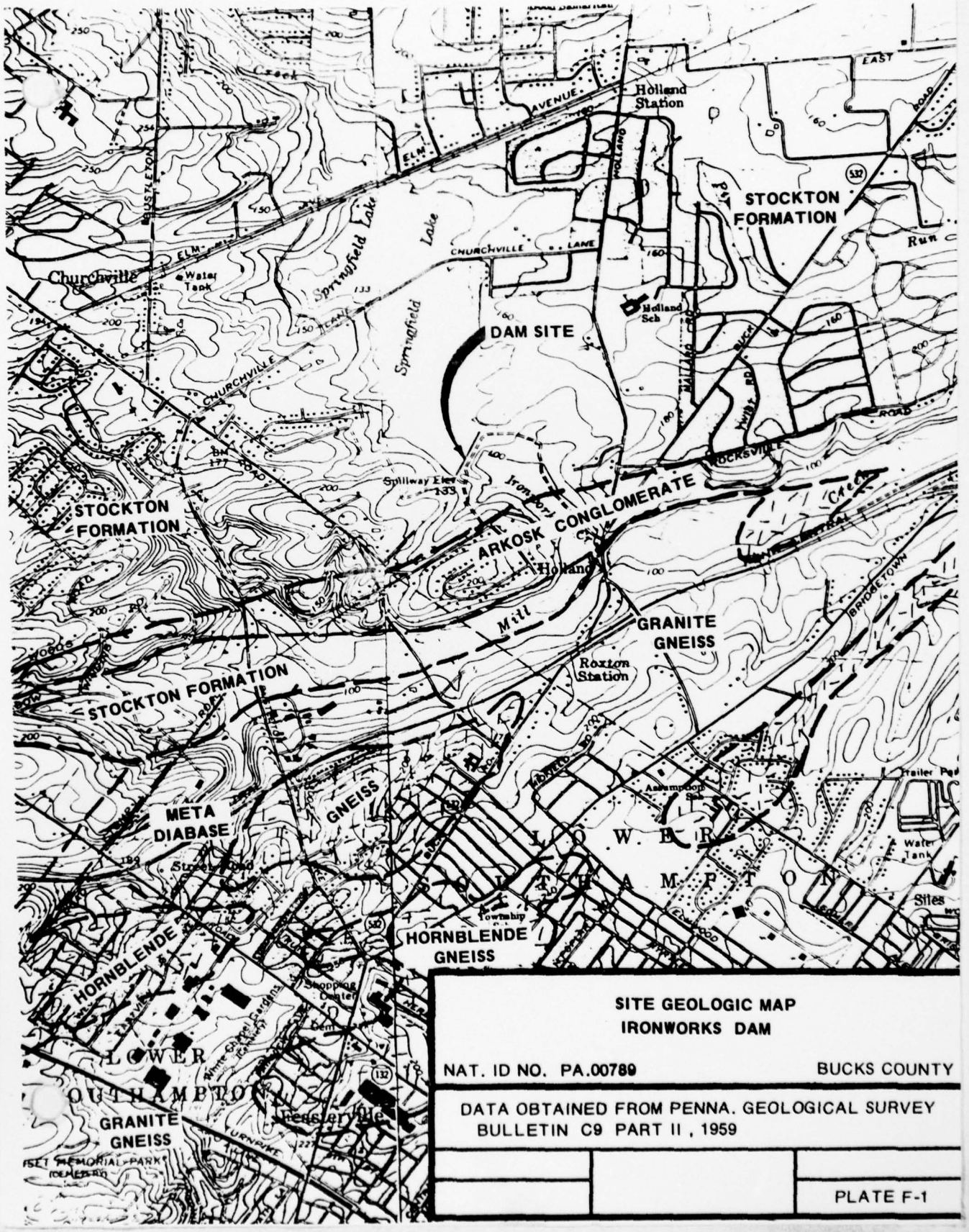
PLATE 6

APPENDIX

F

SITE GEOLOGY
IRONWORKS DAM

Ironworks Dam is located near the southern limit of the Triassic Lowland Section of the Piedmont Physiographic Province. As shown in Plate F-1, the bedrock upon which the dam is constructed consists of the interbedded conglomerate, arkosic sandstone and shale of the Stockton Formation of Triassic age. The bedding in the dam area strikes east-northeast with dips of 12 to 20 degrees to the north-northwest. Rock jointing in the right abutment area strikes northeast and northwest (downstream direction) having near-vertical dips to the southeast (downstream direction) and northeast, respectively. The orientation of bedding planes is favorable for water retention, but the orientation of joint planes and the variable degree of rock weathering relative to rock type would be conducive for downstream seepage. This may have contributed to the area of seepage west of the outlet conduit.



SITE GEOLOGIC MAP
IRONWORKS DAM

NAT. ID NO. PA.00789 BUCKS COUNTY

DATA OBTAINED FROM PENNA. GEOLOGICAL SURVEY
BULLETIN C9 PART II , 1959

PLATE F-1